Boeing Plant 2
Seattle/Tukwila, Washington

Uplands Corrective Measures Study

Volume X:
Corrective Measures
Study Report – Plant 2

Prepared for
The Boeing Company
Seattle, Washington

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List of Abbreviations/Acronyms

Abbreviation/Acronym	Definition
ASTs	aboveground storage tanks
ACMER	Alternative Corrective Measures Evaluation Report
AOC	Area of Concern
AS	air sparging
AWQC	Ambient Water Quality Criteria
BAP	benzo[a]pyrene
BCF	bioconcentration factors
BEHP	bis(2-ethylhexyl)phthalate
bgs	below ground surface
Boeing	The Boeing Company
BTEX	benzene, toluene, ethylbenzene, total xylenes
CAO	corrective action objective
cDCE	cis-1,2-Dichloroethene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CID	contained-in” designation
cm/sec	centimeters per second
CMI	Corrective Measures Implementation
CMS	Corrective Measures Study
CMP	corrugated metal pipe
COC	constituent of concern
COPC	constituent of potential concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSM	conceptual site model
cVOC	chlorinated volatile organic compound
cy	cubic yard
DDC	density-driven convection
DGI	Data Gap Investigation
DO	dissolved oxygen
DQO	data quality objective

Abbreviation/Acronym	Definition
DRPH	Diesel -range petroleum hydrocarbon
DSOA	Duwamish Sediment Other Area
EAB	enhanced aerobic bioremediation
EAD	enhanced aerobic degradation
Ecology	Washington State Department of Ecology
EMF	Electrical Manufacturing Facility
EPI	Environmental Partners, Inc.
ERD	enhanced reductive dechlorination
EMJ	Earle M Jorgensen
FOE	frequency of exceedance
FMCL	final media cleanup level
FRTR	Federal Remediation Technologies Roundtable
GAC	granular activated carbon
gpm	gallons per minute
GRPH	gasoline-range petroleum hydrocarbon
HCID	Hydrocarbon Identification
IC-ICP-MS	ion chromatography inductively coupled plasma mass spectrometry
ICP-AES	inductively coupled plasma atomic emission spectrometry
ICP-MS	inductively coupled plasma mass spectrometry
ICP-DRC-MS	inductively coupled plasma dynamic reaction cell mass spectrometry
IM	Interim Measure
IRIS	Integrated Risk Information System
JFOS	Jorgenson Forge Outfall Site
KCIA	King County International Airport
LDW	Lower Duwamish Waterway
MCL	Maximum Contaminant Level
MDL	method detection limit
mg/day	milligrams per day
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MLLW	mean lower low water

Abbreviation/Acronym	Definition
MoRPH	motor oil range petroleum hydrocarbon
MTCA	Model Toxics Control Act
NAD	North American Datum
NFA	No further action
NGVD	National Geodetic Vertical Datum (1929)
NTR	National Toxics Rule
NTU	Nephelometric turbidity unit
NWTPH	Northwest total petroleum hydrocarbons
NWTPH-Dx	Northwest TPH-diesel/motor oil range hydrocarbons
NWTPH-D	Northwest total diesel-range petroleum hydrocarbons
NWTPH-G	Northwest total gasoline-range petroleum hydrocarbons
OA	Other Area
Order	Administrative Order on Consent
OSWER	Office of Solid Waste and Emergency Response
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	Tetrachloroethene
Plant 2	Boeing Plant 2
PMCL	preliminary media cleanup level
POC	point of compliance
PQL	Practical Quantitation Limit
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
RA	Remediation Area
RBDA	Risk Based Determination Approval
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
RFI	RCRA Facility Investigation
RL	Reporting Limit
RSL	Regional Screening Level
SAP/QAPP	Sampling Analysis Plan / Quality Assurance Project Plan
SCL	Seattle City Light
SL	screening level

Abbreviation/Acronym	Definition
SOB	Statement of Basis
SMS	Sediment Management Standards
SQS	Sediment Quality Standards
SVE	soil vapor extraction
SVOC	semivolatile organic compound
SWMU	Solid Waste Management Unit
TCE	Trichloroethene
TEFs	toxicity equivalency factors
TEQ	toxic equivalency quotient
TMCL	target media cleanup level
TPH	total petroleum hydrocarbon
TSCA	Toxic Substances Control Act
TSD	Treatment Storage and Disposal
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µS/cm	microsiemens per centimeter
USACE	US Army Corps of Engineers
USC	United States Code
USEPA	United States Environmental Protection Agency
UST	underground storage tank
VC	vinyl chloride
VOC	volatile organic compound
VPC	vapor phase carbon
WAC	Washington Administrative Code
WAD	weak acid dissociable
WQS	Water Quality Standards
Work Plan	Data Gap Investigation Work Plan

EXECUTIVE SUMMARY (ES)

This document presents Volume X of the Corrective Measures Study (CMS) Report for The Boeing Company's Plant 2 Facility (Plant 2) at 7755 East Marginal Way South, Seattle/Tukwila, Washington. In 1994, the Boeing Company (Boeing) entered a Resource Conservation and Recovery Act (RCRA) Administrative on Consent (Order) for corrective action for Plant 2 with the United States Environmental Protection Agency (USEPA).

This document describes the cleanup actions that have been conducted at Plant 2 as Interim Measures (IMs) to date, and identifies the remaining areas of impacted soil and groundwater in the Uplands that still require cleanup actions to be performed as corrective measures. The primary objective of Volume X according to the Order is for Boeing to recommend those cleanup actions (referred to as remedial alternatives in the RCRA process) to USEPA. The USEPA will select and direct completion of the remedial alternatives in the Statement of Basis (SOB) decision document. All remedial alternatives recommended as corrective measures at Plant 2 include long-term monitoring and the opportunity to revise or replace a chosen alternative to ensure the actions are successful, and that future facility operations are managed in a way to not negatively affect the sediments, surface waters, or shoreline areas of the Lower Duwamish Waterway that Plant 2 borders.

Since 1994, in conjunction with USEPA approval and oversight, Boeing has completed numerous IMs resulting in the cleanup of a considerable volume of impacted soil and groundwater at Plant 2. Major World War II-era manufacturing facilities have recently (2010-2011) been demolished, and new, state-of-the-art stormwater and utility infrastructures have been constructed. Boeing also recently (2014) completed the final Corrective Measure for contaminated sediments and soils along the Lower Duwamish Waterway bank fronting Plant 2, and constructed extensive habitat areas along the Plant 2 waterfront. These extensive redevelopment projects have included numerous IMs, which are referenced in this Volume X document.

To effectively discuss the corrective measures recommended to address the impacted soil and groundwater remaining in the Plant 2 Uplands, Plant 2 has been divided into nine Remediation Areas (RAs). This Executive Summary describes the objective and content of each section of Volume X, which follows the RCRA process for the evaluation and selection of remedial alternatives. For each RA, this process includes identifying areas where cleanup is required, evaluating possible remedial alternatives for those areas, and then recommending the preferred remedial alternative.

ES1.0 PURPOSE AND SCOPE

The data set for Plant 2 that was initiated with the original 1996 RCRA Facility Investigation[1] (RFI) has been updated over time with data from numerous investigations, IMs, and other data reports. The most comprehensive updates were provided through a number of Data Gaps Investigations (DGIs) conducted between 2005 and 2010, which encompassed the entire Plant 2 property. The

[1] Roy F. Weston, Inc. (Weston). 1996. RCRA Facility Investigation Groundwater Investigation Interim Report. Prepared for The Boeing Company. Seattle, Washington. January 1996.

work plans and data reports from the DGIs comprise Volumes IIIa and b through IXa and b of the CMS Report.

The RCRA unit-by-unit approach used to investigate the facility for the RFI was found to be of limited utility for evaluation of groundwater impacts, which are not necessarily static. Therefore, the DGIs divided Plant 2 into seven study areas based on groundwater flow patterns. The DGI study areas are not analogues to the subsequent RAs that are first introduced in Volume X. This document uses both the DGI and RA frameworks to evaluate and propose corrective measure recommendations. Volume X generally relies on RCRA unit-by-unit descriptions and data when describing soil source control actions and on DGI study area descriptions when addressing groundwater. The Order requires each RCRA unit to be tracked to ensure it is accounted for throughout the process. Volume X accommodates this by establishing geographic RAs, each of which encompasses one or more RCRA units and includes one or more DGI areas to account for the more integrated evaluation of underlying groundwater.

Three corrective actions separate from, but integrated with, the Plant 2 Uplands warrant discussion. First, two Plant 2 RCRA units situated along the Duwamish Waterway, specifically the Duwamish Sediments Other Area (DSOA) and the Southwest Bank (along with the southern shoreline), were previously addressed administratively by USEPA in an earlier Corrective Measures Study Report, a SOB, and an Engineering Design Report. That corrective measure was implemented between 2012 and 2015, and determined to be successfully completed by USEPA. Second, the Electrical Manufacturing Facility (EMF) groundwater plume, which originates on the east side of the King County International Airport (KCIA) and crosses Plant 2, is managed by Boeing with USEPA under an on-going Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Order. Finally, the Jorgensen Forge Outfall Site (JFOS), which occurs primarily on Jorgensen Forge property along the southern Plant 2 property line, was established by USEPA in a separate CERCLA Order held jointly by Boeing and Jorgensen Forge Corporation. The JFOS Order requirements have largely been completed. These three actions, being distinct from but integral to the Plant 2 Uplands CMS process, are included in Volume X by reference.

The Order specifies that activities necessary to correct actual or potential threats to human health and the environment resulting from the release or potential release of hazardous constituents from Plant 2 be evaluated and proposed by Boeing. Since an extensive database has been compiled based on work already been performed, such as IMs and redevelopment projects, and given that such work is on-going in many respects, Volume X content is based on current conditions and sample data available through the following cutoff dates:

- December 31, 2016 for groundwater monitored under the Shoreline Monitoring Well Network, EMF, JFOS, and various IM actions
- January 7, 2013 (Volume IXb of the CMS report) for groundwater throughout the remainder of Plant 2 collected as part of DGI actions
- December 31, 2016 for soil
- December 14, 2011 for concrete and soil used as backfill during the redevelopment project

As such, the data set used in Volume X to describe current conditions collectively represent a snap-shot in time. Data associated with contamination that was removed (primarily soil) through

IMs or other actions have been removed from the data set and replaced with post-action data. Additionally, some construction projects have continued or started after the December 31, 2016 date and any data associated with these projects will be in tracked in the site RCRA database and reviewed for impact on site conditions during preparation of the Corrective Measures Implementation (CMI) work plans. Groundwater activities have continued on site since December 31, 2016 and more current data were used where appropriate and identified in this document.

Given ongoing work by Boeing, additional data will become available and may be applied as appropriate throughout the course of USEPA's review of Volume X and its decision process leading to finalization and approval of the SOB for the Plant 2 Uplands. The CMI phase that follows the SOB will incorporate the newer data and then continuously add to the information available to plan and conduct final cleanup actions throughout Plant 2.

ES1.1 Regulatory Framework

All work supporting the CMS process, including this submittal, has been performed under and consistent with the Order issued by USEPA to Boeing under the authority of Section 3008(h) of the RCRA of 1976, as amended (42 USC 6928(h)). This Order (RCRA Docket Number 1092 01-22 3008[h]) became effective on January 18, 1994. The Order specifies activities and processes to be followed necessary to identify and correct actual or potential threats to human health and the environment resulting from the release or potential release of hazardous constituents from the Plant 2 facility.

The Order also requires an interface between corrective actions for which the USEPA has authority and specific RCRA hazardous waste treatment, storage, and disposal (TSD) units, for which the Washington State Department of Ecology (Ecology) has been delegated authority by USEPA. Under this arrangement, Ecology has responsibility for "closing" the TSD units, through Boeing's actions, within the broader context of the Plant 2 Order. Six of the RCRA units identified in the RCRA Order were operated as regulated TSD units. All six of these units received approval of final closure through work to be performed in conjunction with USEPA authority under the Order (Ecology 2015b). Regarding the administration of these particular TSD units, Boeing and Ecology understand that any residual contamination associated with the units is or may be commingled within the broader Plant 2 setting such that their administration is already being addressed appropriately and fully through the RCRA Order. As such, recommended remedial alternatives for the TSD units will be addressed within the CMS process and Volume X.

ES1.2 Corrective Measures Study Report Organization

The USEPA established the structure of the CMS DGI process and the CMS Report after coordination with Boeing in a May 2, 2006 letter to Boeing[2]. This structure is as follows:

- Volume I – Uplands CMS Conceptual Hydrogeologic Model
- Volume II, Section 1 – Uplands CMS Target Media Cleanup Levels (TMCLs)

[2] US Environmental Protection Agency (USEPA). 2006. Letter to Mr. William Ernst, The Boeing Company, from Mr. Shawn Blocker, USEPA Region 10, regarding: Uplands Corrective Measures Study (CMS) Volume III South Yard Area Data Gap Investigation Report, the CMS Process, and the Uplands Corrective Measures Study (CMS) Volume III 2-60s Area Data Gap Investigation Report, Boeing Plant 2, Seattle/Tukwila, Washington, RCRA Docket No. 1092 01 22 3008(h), USEPA ID No. WAD 00925 6819. May 2, 2006.

- Volume II, Section 2 – Uplands CMS Johnson and Ettinger Site Specific Data Model Report
- Volume II, Section 3 – Background Technical Memorandum
- Volumes III through IX – Uplands CMS Data Gap Investigation Reports (separate volumes for each of the seven Plant 2 study areas, see Figure 1-2); Volumes III through IX each contain two parts:
  - Part A – Uplands CMS Data Gap Investigation Work Plan
  - Part B – Uplands CMS Comprehensive Data Report
- Volume X – CMS Report

This document comprises Volume X and incorporates all other volumes by reference. It summarizes the current environmental conditions and RCRA Order regulatory status of Plant 2, evaluates applicable remedial technologies for those current site conditions, and proposes specific remedial alternatives that Boeing considers necessary or desirable to reach cleanup goals under the Order.

Volume X is presented in a streamlined format to provide clarity and facilitate review. The main body presents the corrective action process and evaluation results in eight sections, which are supplemented by numerous attachments that provide necessary detailed supporting information. Volume X may be read alone, as it includes an abbreviated version of content in Volumes I through IX.

Volume X is divided into eight sections:

- **1.0: Introduction** – describes the scope of the CMS and the site's history, physical setting, geology and hydrogeology, which is described fully in Volume I.
- **2.0: Media Cleanup Levels and Constituents of Concern** – for soil and groundwater, summarizes (TMCLs developed in Volume II, presents updates to the TMCLs, proposes final media cleanup levels (FMCLs), describes the process for identifying constituents of concern (COCs), and summarizes Plant 2 COCs.
- **3.0: Interim Measures and Site Changes** – provides a summary of cleanup actions and physical changes completed at Plant 2 since the RFI was conducted in the mid-1990s.
- **4.0: Current Site Conditions** – describes current soil and groundwater conditions at Plant 2.
- **5.0: Evaluation of Remedial Technologies** – describes the screening process used to identify remedial technologies that may be applicable to Plant 2 in support of the development of remedial alternatives.
- **6.0: Identification of Remediation Areas and Evaluation of Alternatives** – identifies the nine RAs, develops remedial alternatives from the subset of remedial technologies potentially suitable for individual RAs, evaluates the potential alternatives for each RA, and recommends the preferred alternative for each RA.

- **7.0: Recommended Remedial Alternatives** – summarizes the recommended alternatives as the proposed corrective measure for each RA.
- **8.0: References** – lists the references cited in Volume X organized by topic.

ES2.0 MEDIA CLEANUP LEVELS AND CHEMICALS OF CONCERN

Corrective actions at RCRA sites must be protective of human health and the environment and must comply with applicable and relevant standards. Media cleanup levels serve this purpose at Plant 2. Two types of media cleanup levels have been developed to facilitate the evaluation of actions at Plant 2: TMCLs and FMCLs.

ES2.1 Overview of Media Cleanup Levels

TMCLs represent the most conservative cleanup levels that could be applied to any given medium (soil, groundwater, and ambient air) at the site, and are often protective of exposure scenarios that would not occur at Plant 2 due to land use restrictions, engineering and institutional controls, and other factors. Many TMCLs are based on cross-media calculations that are not calibrated to reflect specific site conditions. FMCLs are similar to TMCLs in that they are developed for the various media using the same equations and toxicity factors as the TMCLs, but may be tailored to account for site-specific conditions, including exposure limitations relative to humans and ecological receptors.

TMCLs for Plant 2 soil, groundwater, and air were established in 2011 with USEPA approval of Volume II of the CMS Report. Volume X proposes revisions to TMCLs in light of newly promulgated water quality criteria, updated toxicity factors and partitioning factors, and other rationale.

Volume X also develops proposed FMCLs for each of the Plant 2 constituents of potential concern (COPCs). Within this document, the term “FMCLs” refers to the proposed (i.e., draft) FMCLs. The proposed FMCLs, when approved by USEPA, will no longer be considered draft and will replace all previous cleanup levels and screening levels (SLs) used at the site for corrective measures (with the exception of the current soil-to-groundwater pathway SLs).

Similar to the identification of COPCs, COCs will be determined by comparing sampling results representative of current conditions to the FMCLs.

ES2.2 Overall Data Quality and Usability

Many soil and groundwater samples have been collected at Plant 2 under established sampling, analysis, and quality assurance plans, and have been found acceptable for decisions regarding corrective measures, compliance with the Order, and risk management. In the case of polychlorinated biphenyls (PCBs), ongoing work in the region may subsequently refine and update the analytical methods currently used for groundwater analysis, and will be applied to Plant 2 ongoing corrective actions when available.

ES2.3 Summary of Data Quality

Data quality issues identified during the identification of COPCs and COCs at Plant 2 were addressed through specific plans: 1) a positive bias/false positive problem associated with specific metals (arsenic, cadmium, copper, nickel, selenium, and zinc) in saline groundwater

samples, and 2) the use of a cyanide analytical method that does not match the method used to develop the FMCL regulatory standard. Although the historical problem with these analytical methods did compromise some early data sets, more recent data collection efforts have resolved these issues. In all cases, sufficient data exist to proceed with CMS remedial alternative evaluations and recommendations. In some cases, the recommended remedial alternatives are designed to address the issues involved.

In the future, Boeing will perform groundwater analysis for PCBs using a high-sensitivity analytical method (e.g., USEPA Method 1668) to achieve reporting limits closer to, or less than, the Washington State Surface Water Quality Standards (WQS) established in Washington Administrative Code (WAC) 173 201A. Implementation of this requirement is expected to be timed consistent with implementation of a similar requirement for other areas along the Lower Duwamish Waterway Superfund Site, which includes Boeing Plant 2.

ES2.4 Groundwater Cleanup Levels and COCs

Groundwater FMCLs consider existing and potential future uses of groundwater. The highest beneficial use of groundwater at Plant 2 is discharge to surface water. Groundwater cleanup levels are protective of surface water and sediment quality for use by humans and aquatic species. The point of compliance (POC) for Plant 2 administered by the USEPA under the Order is the Duwamish Waterway, which is represented by monitoring wells installed along the shoreline, collectively referred to as the Shoreline Monitoring Well Network.

The groundwater FMCLs are numerically equivalent to their respective TMCLs, except in cases where a TMCL is below reliably achievable laboratory quantitation limits. In those cases, the FMCL is set to the current practical quantitation limit (PQL).

Groundwater COCs have been determined from a review of current and historical monitoring data and whether an identified constituent has reached the Plant 2 shoreline area as demonstrated by exceedances in samples from the shoreline monitoring well network. Groundwater COCs are summarized as follows:

- Metals – Total arsenic, total copper, and dissolved zinc
- Volatile Organic Compounds – Benzene, cis-1,2-Dichloroethene (cDCE), ethylbenzene, naphthalene, trichloroethene (TCE), and vinyl chloride (VC)
- Polychlorinated Biphenyls (PCBs) – Total PCBs (FMCL will change as noted in ES2.3)
- Petroleum Hydrocarbon Constituents – Monitored using surrogate criteria [Benzene, toluene, ethylbenzene, total xylenes (BTEX) for gasoline range petroleum hydrocarbons (GRPH)] and naphthalene for diesel range petroleum hydrocarbons (DRPH) and motor oil range petroleum hydrocarbons (MoRPH)]

Additionally, four COPCs have been retained as pending groundwater COCs at one or more locations along the Plant 2 shoreline; these are dissolved cadmium, free cyanide, dissolved nickel, and bis(2-ethylhexyl)phthalate (BEHP).

Further details on the nature and extent of the aforementioned COCs and pending COCs are provided in Section 4.0 of this document.

ES2.5 Soil Cleanup Levels and COCs

Soil cleanup levels have been developed based on the long-held understanding that Plant 2, located in the industrial corridor of Seattle, would remain an industrial facility and that Boeing would place an environmental covenant on the site deed to document and ensure this current and future land use. In the development of cleanup levels, it is envisioned that engineering and institutional controls would include, but not be limited to: pavement maintained to reduce infiltration and direct contact with soil; and restricted access to industrial areas.

The following assumptions are made in the development of soil FMCLs:

- The site will remain an industrial facility with the industrial areas of the site remaining under controlled access.
- The industrial areas of the site will remain paved and/or covered by buildings with slab-on-grade foundations. In Volume X, the industrial area is referred to as the paved industrial area.
- The area along the shoreline will consist of unpaved, landscaped areas that transition to the North and South Habitat Areas built in from 2012 through 2015. This unpaved area has limited access and is referred to in Volume X as the unpaved shoreline area.

Soil FMCLs are based on direct contact pathway. Soil SLs protect groundwater quality via a potential leaching pathway. Soil FMCLs apply to paved and unpaved areas of Plant 2 as follows:

- Paved Industrial Area – the FMCLs for this area are protective of industrial workers using a direct contact scenario that includes ingestion, dermal, and inhalation exposure routes. These calculations assume that the site is unpaved and are, therefore, quite conservative.
- Unpaved Shoreline Area – the FMCLs for this area are protective of unrestricted use by the public using a direct contact scenario that includes ingestion, dermal, and inhalation routes, and are also protective of benthic and aquatic species using the Sediment Management Standard's (SMS) Sediment Quality Standards (SQS) criteria. These assumptions are quite conservative since the public has very limited access to this area and the nearest benthic habitat for aquatic species is generally on the west side of the constructed habitat area.

Soil concentrations in the paved industrial area and unpaved shoreline area were also evaluated relative to SLs based on a calculated soil-to-groundwater leaching scenario that does not consider natural attenuation and other site-specific factors that could reduce leaching potential. Groundwater data were used to confirm whether leaching from soil has led to groundwater contamination. The use of current groundwater data to assess this pathway assumes that future conditions will be similar with respect to the amount of stormwater infiltration that could occur. Because of the placement of the environmental covenant that includes the continued use of pavement and buildings in the paved industrial area of the site, this assumption is justified. In the unpaved shoreline area, the more conservative leaching SLs have been retained for evaluation of soil concentrations.

Soil COCs were identified in 2014 with consideration of the above exposure pathways. Soil COCs are summarized as follows:

- Paved Industrial Area – Benzo(a)pyrene Toxic Equivalency Quotient (TEQ), total PCBs, GRPH, DRPH, MoRPH, free cyanide, cDCE, TCE, VC, and copper
- Unpaved Shoreline Area – Total PCBs, GRPH, DRPH, MoRPH, cDCE, and TCE

ES3.0 INTERIM MEASURES AND SITE CHANGES

ES3.1 Soil Removal Actions – Construction Projects, Interim Measures, and Redevelopment

Significant work has been completed at Plant 2 since the Order was put in place in 1994 to address soil and groundwater contamination as well as source control and redevelopment objectives. Between approximately 1995 and December 2016, more than 98 soil excavations/removal actions have been conducted on site. In addition, numerous above and below ground structures, concrete slabs, and monitoring wells have been decommissioned, demolished, and/or removed as a result of redevelopment and remedial activities throughout the property. This work included the following:

- The removal of approximately 60,000 cubic yards (cy) of concrete slabs, foundations, and underground structures.
- The removal and disposal of approximately 1,200 cy of concrete managed as Toxic Substances Control Act (TSCA) waste.
- The removal and disposal of approximately 60,000 cy of impacted soil.
- The processing, analysis and placement of approximately 113,500 tons of recycled crushed concrete used as backfill for construction projects.
- The import and placement of approximately 125,000 tons of clean soil backfill.
- Placement of approximately 30 acres of asphalt pavement over the soil surface following soil cleanups in the area of the demolished buildings in the 2-40s / 2-60s Area.
- Demolition of the tunnels under Buildings 2-40, 2-41, and 2-49, and placement of clean fill material and recycled crushed concrete backfill in the tunnel excavations (at least 1.5 feet above the groundwater table).
- Construction of a new stormwater system, including 14,000 linear feet of new stormwater lines, five lined bioswales, three stormwater treatment vaults, and three outfalls in the 2-40s, 2-60s, 2-66, and 2-31 areas.
- Removal of approximately 46,000 cy of uplands and bank soils combined with approximately 16,300 cy of sediment as part of the DSOA and Southwest Bank remedy and construction of habitat areas.
- Decommissioning 173 monitoring wells no longer serving a purpose.

ES3.2 Soil and Crushed Concrete Backfill

During the demolition and redevelopment activities from 2010 to 2012, soil, stormwater, and concrete were managed in accordance with USEPA-approved IM work plans and completion reports that document site activities including field monitoring, soil sampling, and waste disposition (Section 8.3). Attachment S3B presents analytical data on crushed concrete backfill and soil backfill and location information. Impacted soils were removed in specific target

excavations during the 2010 to 2012 demolition and redevelopment activities (Figure 3-1 and Table 3-1). Attachment S3A (on USB) contains the documents and communication that summarize historical excavations and soil removal actions associated with IMs and construction projects presented in Table 3-1. Data corresponding to excavated soil were removed from the Plant 2 active database and replaced with post-construction or post-IM sampling results to represent current site conditions.

ES3.3 DSOA and Southwest Bank Sediment Corrective Measure

The DSOA and Southwest Bank Corrective Measure were approved by USEPA in 2011. Construction began in 2012, the corrective measure was completed in 2015, and long-term monitoring of the sediment is ongoing. The implementation report for the DSOA and Southwest Bank Corrective Measure is included in Attachment S3A (AMEC et al. 2015). The work along the shoreline bank also included the construction of two large habitat areas. Section 8.0 of this report references key decision, design, and construction completion documents for this work.

ES3.4 OA 11 Interim Measure

In early 2016, the RCRA program and Boeing determined that the corrective measure for OA 11 should be performed as an IM jointly with the TSCA program under a RBDA. Performing this IM allowed Boeing to complete property improvements necessary for stormwater compliance in that area of Plant 2.

The IM consisted of excavation of soil primarily impacted with PCBs and TPH; low levels of cVOCs (i.e., TCE and VC) were also concurrently removed. The excavation was completed between September 6 and 20, 2016. A total of approximately 50 cy of Subtitle C soil and pipe debris totaling 124 tons, and approximately 650 cy of Subtitle D soil totaling 1,020 tons were excavated as part of the IM. In addition, approximately 78 tons of debris (including the former transformer pad, inactive stormwater features, and other miscellaneous debris) were removed and transported to a Subtitle D landfill for disposal. The construction completion report detailing the OA 11 IM is included in Attachment S3A.

Boeing has completed the approved scope of RCRA requirements in OA 11 with the completion of the IM in 2016; additional investigation data suggests a source other than Boeing for the PCB contamination discovered immediately south of OA 11 on the Jorgensen Forge property.

ES3.5 Groundwater Interim Measures

Numerous groundwater IMs have been performed or are currently being performed at Plant 2. Groundwater IMs are generally designed to contain and/or reduce contaminant mass within areas with groundwater impacts. Completed IMs include significant source control activities to remove contaminated soil, containment of the major solvent (i.e., TCE) releases within sheetpile containment structures, mass removal of contaminants from within those sheetpiles, and in-situ treatment of both petroleum and chlorinated volatile organic compound (cVOC) releases using a variety of techniques. Noteworthy IMs are summarized here and in Section 3.0; details are presented in Section 3.0 attachments.

2-66 Sheetpile IM Series – Installation of a sheetpile containment structure (sheetpile) around soil and groundwater containing elevated concentrations of cVOCs near the former 2-66 Building area to prevent migration and transport of contaminants through the subsurface to the Duwamish Waterway. A series of IMs based on different remediation technologies have been conducted in

conjunction with the 2-66 Sheetpile, resulting in cleanup of approximately 99 percent of the cVOCs present. Remediation technologies included the following:

- Installation and operation of two density-driven convection (DDC) well systems to remove cVOC vapor from soil and strip cVOCs from groundwater inside the sheetpile and treat the vapor with granular activated carbon (GAC) followed by permanganate-impregnated zeolite. The spent GAC generated by the DDC system was incinerated at an off-site facility destroying the accumulated cVOCs. DDC was terminated when the point of diminishing returns with that technology was reached.
- Performance of enhanced reductive dechlorination (ERD) within the sheetpile to destroy residual concentrations of cVOCs that remained following operation of the DDC system. ERD was initiated by injecting a nutrient solution into the groundwater to enhance reducing geochemical conditions in the aquifer, which are favorable for reductive dechlorination of cVOCs.
- Excavation and landfilling off site of cVOC contaminated vadose soil from within the sheetpile to remove contaminant source mass.
- Continuation of long-term ERD in which a proprietary emulsified oil remediation substrate was applied to the top of the groundwater table prior to backfilling the excavation (described above) to further enhance favorable reductive geochemical conditions.

Diesel Recovery Area IM – A product extraction well and a product recovery system were installed to remove floating diesel fuel in monitoring wells near the southwest corner of former 2-66 Building. The system was turned off when the point of diminishing returns was reached.

OA 12 ERD IM – This IM was conducted on cVOCs present in groundwater beneath former 2-63 Building based on ERD technology proven effective at reducing the areal extent of the cVOC plume in the A-Level of the aquifer.

OA 9 Enhanced Aerobic Degradation (EAD) IM – This IM implemented bioventing for soil and EAD for groundwater at OA 9. The introduction of oxygen into subsurface soil and groundwater enhanced the biological degradation of petroleum hydrocarbons and non-chlorinated VOCs to acceptable levels through aerobic metabolism.

Western Portion of 2-31 Area – Impacted soil was excavated from the west portion of 2-31 Building and a proprietary emulsified oil remediation substrate was mixed into the top of groundwater prior to backfilling to enhance reducing geochemical conditions in the aquifer, which are favorable for ERD.

2-10 Area North and South Sheetpiles IM Series – Two sheetpiles were installed around soil and groundwater containing elevated concentrations of cVOCs in both the north and south ends of the 2-10 Building to prevent migration and transport of contaminants through the subsurface. Several IMs based on different technologies have been conducted in association with the two 2-10 Building sheetpiles that included the following:

- Installation and operation of soil vapor extraction (SVE) systems at the sheetpile locations to remove and capture cVOC mass as vapor from vadose-zone soil inside the sheetpiles.

- Performance of ERD to destroy concentrations of cVOCs contained in shallow groundwater. ERD was initiated by injecting a nutrient solution into the aquifer to enhance reducing geochemical conditions in the aquifer, which are favorable for ERD.

ES3.6 Adjacent Cleanup Actions at Jorgensen Forge

Directly south of Plant 2 is the Jorgensen Forge property, an active aluminum, steel, and specialty alloy firm. There are three active cleanup initiatives on the site. These include an Ecology Agreed Order with Earle M Jorgensen under the Model Toxics Control Act (MTCA) for cleanup of uplands contamination including petroleum hydrocarbons, chlorinated solvents, metals, and PCBs; a USEPA Order under the CERCLA held jointly by Jorgensen Forge and Boeing for cleanup of two historical stormwater outfalls along the property line; and a second USEPA Order under CERCLA held by Earle M Jorgensen for cleanup of the bank and sediments associated with the Jorgensen facility. These actions are documented elsewhere in the public record but since each required coordination in some manner relative to the Plant 2 RCRA Order, each is referenced in this document where applicable.

ES3.7 Electronics Manufacturing Facility Plume

The EMF plume originates from a former Boeing facility that operated on the east side of the KCIA. Past activities at the EMF site resulted in a release of TCE to the ground, which contaminated groundwater. The EMF cVOC plume was transported downgradient by natural groundwater flow from the former EMF site in a westerly direction across KCIA and into Plant 2. Within Plant 2, the EMF plume is found 30 to 60 feet below ground surface (bgs) interval referred to as B-level of the aquifer.

The EMF plume is being remediated using ERD under a separate CERCLA Order administered by USEPA. The most recent and most successful remedial technology to degrade cVOCs within the EMF plume is ERD. Boeing is conducting ongoing nutrient substrate injections to promote and maintain geochemical conditions that are favorable for ERD, and groundwater monitoring to track remedial progress in the EMF plume. Groundwater monitoring data for the EMF plume demonstrate that ERD has successfully decreased the size, concentration, and downgradient extent of the EMF plume. TCE and its daughter products have been effectively reduced to levels comparable to the Plant 2 FMCLs throughout the plume in the Plant 2 area.

Boeing will continue to implement the ERD remedial technology and monitor groundwater quality throughout the EMF plume through the EMF CERCLA Order, and ensure coordination between the RCRA Order and the EMF CERCLA Order, to achieve FMCLs over time.

ES4.0 CURRENT SITE CONDITIONS

Groundwater and soil IMs and other actions summarized in Section 3.0 of this document, coupled with other Plant 2 redevelopment activities, have substantially changed and improved site conditions from those originally documented in the RFI. Groundwater monitoring associated with IMs and ongoing monitoring of the shoreline monitoring well network also provide an ongoing set of historical and current data on the nature and extent of current soil and groundwater contamination.

To simplify the discussion of soil and groundwater that remains at concentrations exceeding FMCLs, COCs have been compiled into 11 COC groupings, as follows:

COC Group	Constituents in COC Group
cVOC	TCE cDCE VC
BTEX	Benzene Ethylbenzene GRPH
Arsenic	Arsenic
CuZn	Copper Zinc
Cyanide	Free Cyanide
DRPH	DRPH MoRPH Naphthalene
PCBs	PCBs
cPAHs	Benzo(a)pyrene TEQ
Pending COCs	
BEHP	BEHP
Cadmium	Cadmium
Nickel	Nickel

Section 4.0 of this document provides information pertaining to the COC groups and individual COCs and their occurrences in soil and groundwater. Extensive figure and table attachments accompany Section 4.0 in keeping with the extensive data set available for Plant 2. Soil data in Volume X are generally presented in the standard depth intervals established for Plant 2 (i.e., 0 to 1 feet bgs, 1 to 6 feet bgs, and 6 to 11 feet bgs). In a similar manner, groundwater data are reported in reference to depths within the Duwamish Valley Aquifer at intervals designated as the A-Level (upper 30 feet bgs), B-Level (30 to 60 feet bgs), and C-Level (60 feet bgs and deeper).

ES5.0 EVALUATION OF REMEDIAL TECHNOLOGIES

Following development of FMCLs and an evaluation of site media with respect to exceedance of COCs, a comprehensive list of remedial technologies was screened for effectiveness with respect to Plant 2 soil and groundwater. Evaluation steps are summarized here.

ES5.1 Initial Remedial Technology Screening

An initial screening was conducted by comparing the Plant 2 COC groups with all applicable treatment technologies presented on the Federal Remediation Technologies Roundtable (FRTR) Treatment Technologies Screening Matrix. Technologies that rated as average or above average in the matrix were retained for further evaluation in a process that identifies the most appropriate technologies to be considered for use in the remaining required corrective measures at Plant 2.

ES5.2 Remedial Technology Screening for Site-Specific Conditions

The subset of technologies retained in Section 5.1 was re-screened with respect to site-specific conditions and future land use. This eliminated many technologies deemed not applicable to Plant 2 conditions, and established the following list of remedial technologies suitable for assembling into remedial alternatives for Plant 2 RAs in accordance with the RCRA process:

- Enhanced Reductive Dechlorination (ERD)
- Enhanced Aerobic Degradation (EAD)
- Air Sparging/Soil Vapor Extraction (AS/SVE)
- Bioventing
- Excavation with Off Site Disposal
- Engineering Controls
- Institutional Controls
- Long-term Groundwater Monitoring
- Short-term Groundwater Monitoring

The preceding list is essentially comprised of technologies proven to be effective in managing and reducing contamination at Plant 2. These technologies have been implemented in association with IMs or cleanup action conducted on site. In some instances, the persistence of some recalcitrant COCs may require further evaluation in consultation with USEPA and refinement or replacement of the implemented corrective action (i.e., Adaptive Management), to achieve FMCLs within a specific RA. Adaptive Management is a process, rather than a technology, and is intended to address specific areas and constituents that do not achieve corrective action goals within a reasonable timeframe.

Finally, in some areas current data may indicate that corrective action is not required. In these cases, a remedial technology of “Corrective Action Not Required” is included for consideration.

ES6.0 IDENTIFICATION OF REMEDIATION AREAS AND EVALUATION OF ALTERNATIVES

RAs with impacted soil and/or groundwater are identified in Section 6.0. Two or more potential remedial technologies from the list established in Section 5.0 were assembled into remedial alternatives to address contamination within each RA. Remedial alternatives must meet the RCRA alternative evaluation standards and were scored from 1 to 5 with respect to the RCRA “other factors” evaluation criteria. A total net benefit score was then calculated for each alternative, and compared to a maximum net benefit score of 30. These scores were considered when selecting the final remedial alternative proposed for implementation as the corrective measure for each RA. The result of the RCRA alternatives-selection process is summarized for each RA below.

ES6.1 Remediation Area Identification

RAs are discrete areas of Plant 2 with similar or continuous hydrogeologic conditions, COC groups, and FMCL exceedances in soil and/or groundwater. Nine RAs have been established at Plant 2 (Figures 6-1 and 6-2):

- **RA 1 – 2-10 North Sheetpile Area:** RA 1 is in the paved industrial area within the 2-10 Building. A small portion of the RA where contamination extends beyond the sheetpile containment is in the unpaved shoreline area below the 2-10 Building overhang. The original source of contamination at RA 1 is a former TCE degreaser associated with RCRA Unit AOC 2 10.3A. RA 1 has been the subject of several IMs. Areas of groundwater with cVOC concentrations exceeding FMCLs were identified as the primary issue in RA 1.
- **RA 2 – 2-10 South Sheetpile Area:** RA 2 is in the paved industrial area within the 2-10 Building. A small portion of the RA where contamination extends beyond the sheetpile containment is in the unpaved shoreline area below the 2-10 Building overhang. The original source of contamination at RA 2 is a former TCE degreaser associated with RCRA Unit AOC 2 10.3A. RA 2 has been the subject of several IMs. Areas of groundwater with cVOC concentrations exceeding FMCLs were identified as the primary issue in RA 2.
- **RA 3 – 2-31 Area:** RA 3 is an area previously covered by a portion of the 2-31 Building that was demolished as part of the 2010-2012 redevelopment project. RA 3 is primarily in the paved industrial area, but a small portion extends a bit into the unpaved stormwater management area. The original source of contamination at RA 3 is a former TCE degreaser associated with RCRA Unit AOC 2-31.21 located within the footprint of the un-demolished portion of the 2-31 Building, and TCE supply piping that was removed in 2011. RA 3 has been the subject of several IMs. Areas of groundwater with cVOC concentrations exceeding FMCLs were identified as the primary issue in RA 3. RA 3 also includes the presence of crushed concrete used in a few locations to backfill tunnel excavations and placed above the water table in this area during the 2010-2012 demolition/redevelopment.
- **RA 4 – 2-66 Sheetpile and Surrounding Area:** RA 4 includes both paved industrial and unpaved shoreline areas in the southwest part of Plant 2. RA 4 contains groundwater with COC concentrations exceeding the FMCLs for cVOCs, GRPH/BTEX, DRPH/naphthalene, various metals, free cyanide, and PCBs. RA 4 has been the subject of several IMs. The original sources of cVOC contamination in RA 4 are a former TCE degreaser associated with RCRA Unit AOC 2-66.53 and a former TCE storage tank decommissioned in the late 1980s.
- **RA 5 – South Yard Area:** RA 5 is within the paved industrial area along the southern boundary of Plant 2; it contains groundwater with concentrations of cVOCs, BTEX, arsenic, zinc, and DRPH that exceed their respective FMCLs. In soil, PCBs and MoRPH are the only COC groups detected in RA 5 at concentrations greater than the applicable FMCLs. RA 5 has been the subject of several IMs. The main source of cVOC in RA 5, the former cisterns (SWMUs 79.A and 79.B), were removed and excavated in the 1990s.
- **RA 6 – OA 18 Area:** RA 6 is within the paved industrial area centered on RCRA Unit OA 18, Building 2-40 East Parking Lot Area. The RFI identified a SVOC-impacted area with a dark, black-stained fill observed in soil borings from 2 to 6 feet bgs. RA 6 has been the subject of several IMs. RA 6 contains cPAHs, TPH, naphthalene, and free cyanide in soil at concentrations greater than their respective FMCLs.

- **RA 7 – Unpaved Shoreline Area:** RA 7 is the unpaved shoreline area located west of the paved industrial area throughout Plant 2 and is adjacent to the Habitat Area along most of the length of Plant 2. North of the South Park (14th Avenue) Bridge, RA 7 consists of the unpaved shoreline area collectively fronting the Duwamish Waterway, the Habitat Area, and Slip 4, and includes lined stormwater bioswales and treatment vaults. South of the bridge, RA 7 fronts the Duwamish Waterway and the Habitat Area. From 2010 to 2012 as part of redevelopment, lined stormwater bioswales and treatment vaults were installed in the unpaved shoreline area as part of the new stormwater system. RA 7 has been the subject of several IMs. Within RA 7, TCE, GRPH, DRPH, and MoRPH exceed their FMCLs in a single location near a lined stormwater swale.
- **RA 8 – Paved Industrial Area:** RA 8 includes all portions of the paved industrial area not contained within the other RAs. RA 8 is covered by concrete and asphalt paving, buildings, parking, roadways, and small landscape strips. A large portion of the paved industrial area south of the bridge was remediated as part of the 2010-2012 demolition/redevelopment project during which impacted soil was removed and tunnel excavations were backfilled above the water table with crushed concrete. RA 8 has been the subject of several IMs. The primary issue in RA 8 is the presence of FMCL exceedances of cVOCs, benzene, naphthalene, arsenic, copper, zinc, nickel, free cyanide, and PCBs in several isolated locations.
- **RA 9 – OA 11 Area:** RA 9 is within the paved industrial area along the southern boundary of Plant 2 and includes both the former 2-72 Building and the former West Bank (utility) Substation. RA 9 has been the subject of several IMs. Most recently, PCB- and TPH-impacted soil was excavated in an IM performed in conjunction with the Toxics Substances Control Act (TSCA) program under a Risk Based Disposal Approval (RBDA). The OA 11 soil IM included excavation, removal of substation structures and inactive stormwater components, disposal of materials, and site restoration and paving and resulted in the completion of corrective actions for RA 9.

ES6.2 Evaluation of Remedial Alternatives

In Section 6.0, remedial technologies retained from the screening process described in Section 5.0 of Volume X are used to develop a series of two or more RA-specific remedial alternatives. The series of alternatives are evaluated and then the best remedial alternative for each RA is recommended as the corrective measure for RA 1 through RA 9 in the following series of steps.

For each RA, remedial technologies that are potentially applicable are evaluated and assembled into remedial alternatives using a focused approach that:

- Considers the extent, nature, and complexity of the contamination
- Addresses the corrective action objectives
- Identifies appropriate, implementable remedies based on good engineering and site management practices

To focus the evaluation and assembly of technologies into alternatives to be considered for each RA, all technologies identified in the initial screening were first filtered down to those considered

suitable. Once technologies were assembled into remedial alternatives for specific RAs, they were evaluated against the following RCRA alternative evaluation standards and other factors:

1. Protect human health and the environment
2. Attain FMCLs
3. Control the source of releases to reduce or eliminate, to the extent practicable, further releases that may pose a threat to human health and the environment
4. Comply with any applicable standards for management of wastes (with or without waivers)
5. Other factors
    a. Long-term reliability and effectiveness
    b. Reduction in the toxicity, mobility, or volume of wastes
    c. Short-term effectiveness
    d. Implementability
    e. Cost
    f. Restoration timeframe (Not identified as an “other factor” under the USEPA guidance document but added by Boeing)

ES6.3 Remedial Alternatives Evaluated

The series of RA-specific remedial alternatives were evaluated and ranked according to the above factors, resulting in eight sets of remedial alternatives:

- AS/SVE
- Bioventing
- Corrective Action Not Required with Controls
- ERD
- ERD and Excavation with Off-Site Disposal
- ERD followed by EAD
- ERD, EAD and Excavation with Off-Site Disposal
- Excavation with Off-Site Disposal

These remedial alternatives are scored, resulting in the most optimal action being recommended for each of the nine RAs. Note that the above process is focused on the technically-oriented remedial alternatives. Remedial alternatives are paired with engineering and institutional controls such as paving, access controls, and environmental covenant restrictions that apply more uniformly throughout Plant 2.

ES7.0 RECOMMENDED REMEDIAL ALTERNATIVES

The corrective action alternatives evaluation process, results in a recommended remedial alternative for each RA. This process results in the recommendation of remedial alternatives that are most likely to successfully achieve FMCLs as the corrective measures for each RA. The proposed remedial alternatives and the RAs to which they apply are listed below. Each would be implemented with engineering and institutional controls that apply throughout Plant 2; adaptive management processes may be implemented if warranted by future data collection and evaluation. Through the adaptive management process, adjustments to how the recommended remedial alternative is implemented and/or monitored would be considered by USEPA and Boeing, and applied where necessary to ensure FMCLs are achieved.

- **Enhanced Reductive Dechlorination (ERD)**
  - RA 1 – 2-10 North Sheetpile Area
  - RA 2 – 2-10 South Sheetpile Area
  - RA 3 – 2-31 Area
  - RA 4 – 2-66 Sheetpile and Surrounding Area

  ERD is an effective and proven technology that has been successfully used at Plant 2 in multiple locations. In addition to implementing the ERD technology, the ERD alternative long-term groundwater monitoring for target COCs, and short-term groundwater monitoring for selected COCs. An important benefit of using ERD will be making use of existing infrastructure such as the substrate injection wells and monitoring wells that are already being used for ongoing ERD implementations in multiple locations.

- **ERD and Excavation with Off-Site Disposal**
  - RA 5 – South Yard Area

  Similar to the ERD alternative described above, this alternative adds excavation with off-site disposal to meet MoRPH and PCB soil FMCLs and support removal of soil potentially contributing as a source to groundwater exceedances.

- **Excavation with Off-Site Disposal**
  - RA 6 – OA 18 Area
  - RA 8 – Paved Industrial Area, Several Spot Locations

  Excavation with Off-Site Disposal is the corrective action alternative with the greatest total net benefit for RA 6 and RA 8. Previous actions at Plant 2 have demonstrated that this technology is effective and highly implementable. In addition to excavation and long-term and short-term groundwater monitoring applicable to specific COCs.

- **Bioventing**
  - RA 7 – Unpaved Shoreline Area, One Spot Location Adjacent to a Stormwater Swale

  Bioventing is the corrective action alternative with the greatest total net benefit for RA 7. An active bioventing system including bioventing wells, air distribution piping, and a blower will be installed. Air will be injected through the wells to treat soil impacted with GRPH, DRPH, and MoRPH. Blower operation and maintenance activities would consist of regular checks of the blower operation and calibration of the airflow rates. In addition to

implementation of the bioventing technology, long-term monitoring for cVOCs, and short-term monitoring for arsenic, nickel, free cyanide, and PCBs are included in this alternative.

- **Corrective Action Not Required (with Controls and Monitoring)**

  - RA 9 – OA 11 Area

  Following completion of the 2016 OA 11 IM, the current data set indicates that further corrective actions for this RA are not required for soil contamination. Adaptive Management will be pursued in coordination with USEPA if either short- or long-term groundwater monitoring demonstrate groundwater does not meet the applicable TMCLs/FMCLs.

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FOREWORD

United States Environmental Protection Agency (USEPA) and The Boeing Company (Boeing) identified the need for additional investigative work at the Boeing Plant 2 (Plant 2) facility in Seattle/Tukwila, Washington during the preparation of the Uplands Corrective Measures Study (CMS) to augment the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI; Weston 1996). This report presents the comprehensive data set for Plant 2 including the results of the data gap investigations (DGI). The RFI used a RCRA unit-by-unit approach to investigate the facility when corrective measures were being evaluated for groundwater. This unit-by-unit approach was determined to be inadequate for selecting remedies because of the integrated nature of soil and groundwater contaminant distributions at Plant 2. The Plant 2 data set provides the basis for the evaluation of remedial alternatives and proposed remedies identified for Plant 2. The in-water and shoreline portion of Plant 2 situated within and immediately adjacent to the Duwamish Waterway, known as the Duwamish Sediment Other Area (DSOA) and Southwest Bank, has been managed with USEPA as a Corrective Measure in a manner separate from but integrated with the uplands portion of Plant 2.

All work supporting the CMS process, including this submittal, has been performed under and consistent with the Administrative Order on Consent (Order) issued by USEPA to Boeing under the authority of Section 3008(h) of the RCRA of 1976, as amended (42 United States Code [USC] 6928(h)). This Order (RCRA Docket Number 1092 01-22 3008[h]) became effective on January 18, 1994. The Order specifies activities necessary to correct actual or potential threats to human health and the environment resulting from the release or potential release of hazardous constituents from the Plant 2 facility, which is located at 7755 East Marginal Way South, Seattle/Tukwila, Washington. This document (Volume X of the CMS Report) is based on analysis of current facility conditions (corresponding to the end of 2016) and environmental samples collected through the following dates:

- December 31, 2016 for groundwater
- December 31, 2016 for soil
- December 14, 2011 for concrete and soil used as backfill

These sampling dates were set to allow preparation of this document despite the ongoing work at Plant 2, in which data from sampling activities continues to be generated. Given ongoing work by Boeing, additional data will be available throughout the course of USEPA's review of Volume X and its decision process leading to the preparation of the Statement of Basis (SOB) for the upland areas of Plant 2. The Corrective Measures Implementation (CMI) phase that follows the SOB will incorporate any newer data and add to the information available to plan and conduct final cleanup actions throughout Plant 2.

The USEPA established the structure of the CMS data gap investigation and reporting process in its May 2, 2006 letter to Boeing (USEPA 2006). To complete the CMS process, Boeing and USEPA agreed to the content and structure of the CMS as follows (see below for reference citations):

- Volume I – Uplands CMS Conceptual Hydrogeologic Model
- Volume II, Section 1 – Uplands CMS Target Media Cleanup Levels (TMCLs)

- Volume II, Section 2 – Uplands CMS Johnson and Ettinger Site Specific Data Model Report – withdrawn
- Volume II, Section 3 – Background Technical Memorandum
- Volumes III through IX – Uplands CMS DGI Reports (one for each of the seven Plant 2 Data Gap Investigation study areas); Volumes III through IX each contain two parts:
    - Section a – Uplands CMS DGI Work Plan
        - Section b – Uplands CMS Data Report (DGI Report)
- Volume X – CMS (Alternatives) Report

This document represents Volume X of the CMS Report. It documents the current condition and regulatory status of the upland portions of Plant 2 as a summary of Volumes I and III through IX. It also presents TMCLs as approved by USEPA (Volume II) and proposes final media cleanup levels (FMCLs) for approval. Within this document, the term FMCLs refers to the proposed (or draft) FMCLs. The proposed FMCLs, when approved by USEPA, will no longer be considered draft and will replace all previous cleanup levels and screening levels used at the site for corrective measures (with the exception of the current soil-to-groundwater pathway screening levels).

This report evaluates potential alternatives for further required remediation, and proposes specific remedial alternatives that Boeing considers necessary or desirable to complete all objectives under the Order. Boeing and USEPA have further agreed that this report will "contain the results from the DGI and all other historical data that were used to identify the DGI in the Work Plans," and will not repeat much of the general interpretive content included in the prior volumes.

Volumes III through IV present the DGI Work Plans and reports for the seven DGI areas at Plant 2. DGI Work Plans are designated as "a" for each area investigation, whereas DGI Reports correspond to the "b" volumes. These reports are included by reference in Section 8 of this document. Electronic copies of these documents are provided in Attachment S1A on the USB.

Additional attachments to Volume X are provided electronically to 1) provide necessary details that support the discussion in the main body of the text that would have been distracting to the reader if included in the main body, and 2) provide historical documents in electronic format to allow the reader to easily locate information contained in references cited. An Attachment Foreword is provided with the attachments to assist the reader in locating pertinent information within each attachment section.

1.0 INTRODUCTION

1.1 Purpose/Scope

This document represents Volume X of the Corrective Measures Study (CMS) for Boeing Plant 2 (Plant 2) and completes the CMS process for the upland portions of Plant 2. The CMS for the in-water portions of Plant 2 was completed in March 2011 (AMEC and Floyd|Snider 2011a), followed by the Statement of Basis (SOB) for the in-water portion in March 2011. Construction of the in-water corrective measure began in 2012 and was completed in 2015.

This document provides a detailed summary of the soil and groundwater data in the uplands portion of Plant 2, which was used to evaluate and propose appropriate corrective measures. Soil and groundwater data obtained during the Resource Conservation and Recovery Act Facility Investigation (RFI) data gap investigations (DGIs) combined with numerous construction projects and interim measures (IMs) was used in this evaluation. The data used in Volume X to describe current conditions represents a snap-shot in time corresponding to the end of 2016 except as noted. The study areas investigated during the DGI are (from south to north): the South Yard Area, 2-60s Area, 2-66 Area, 2-40s Area, 2-31 Area, 2-10 Area, and North Area. Analytical data from these study areas are presented in the following reports, which were previously submitted to the United States Environmental Protection Agency (USEPA):

- Uplands Corrective Measures Study Volume IIIb South Yard Area (EPI and Golder 2007a [March 2007])
- Uplands Corrective Measures Study Volume IVb 2-60s Area (EPI and Golder 2007b [May 2007])
- Uplands Corrective Measures Study Volume Vb 2-66 Area (EPI and Golder 2007c [October 2007])
- Uplands Corrective Measures Study Volume VIb 2-40s Area (EPI and Golder 2009d [December 2009])
- Uplands Corrective Measures Study Volume VIIIb 2-31 Area (EPI and Golder 2010a [July 2010])
- Uplands Corrective Measures Study Volume IXb 2-10 Area (EPI and Golder 2011 [March 2011])
- Uplands Corrective Measures Study Volume VIIb North Area (EPI and Golder 2009b [October 2009])

Electronic copies of these documents (Work Plans correspond to “a” volumes and DGI Reports correspond to “b” volumes) are provided in Attachment S1A on the USB.

This document does not present data for or include remediation technology evaluations and recommendations for the Duwamish Sediment Other Area (DSOA) and the Southwest Bank because these areas were evaluated separately as part of the in-water portions of the site and have now undergone corrective measures. Nor does it present data for or include remediation technology evaluations and recommendations for the Jorgenson Forge Outfall Site (JFOS) as it was evaluated separately and has now undergone corrective measures. For reference purposes, key documents related to the DSOA, the Southwest Bank, and JFSO are identified in Section 8.2.

The Administrative Order on Consent (Order) also requires an interface between corrective actions for which the USEPA has authority, and specific Resource Conservation and Recovery Act (RCRA) hazardous waste treatment, storage, and disposal (TSD) units, for which the Washington State Department of Ecology (Ecology) has been delegated authority by USEPA. Under this arrangement, Ecology has responsibility for "closing" the TSD units, through Boeing's actions, within the broader context of the Plant 2 Order. Six of the RCRA units identified in the RCRA Order were operated as regulated TSD units (Figures 1-4, 1-8, 1-9, and 1-10). All six of these units received approval of final closure through work to be performed in conjunction with USEPA authority under the Order (Table 1-1, Ecology 2015b). Regarding the administration of these particular TSD units, Boeing and Ecology understand that any residual contamination associated with the units is or may be commingled within the broader Plant 2 setting such that their administration is best and already being addressed appropriately and fully through the RCRA Order. As such, recommended remedial alternatives for the TSD units will be addressed within the CMS process and Volume X. Following completion of the corrective measures, Boeing will submit a letter to Ecology documenting cleanup of residual contamination associated with the TSD units. The letter will include a description of corrective measures and provide soil and groundwater data and figures to verify cleanup levels have been met.

1.2 Corrective Measures Study Report Organization

This document (Volume X) is presented in a concise format. The main body of the report presents the corrective action process and evaluation. Each section of this document has a corresponding attachment containing detailed documentation including background and historical information, calculations, data tables, figures, related studies, and previously submitted information to support the text presented in the main body of the document. The accompanying USB includes this document (Volume X) and all attachments.

This document is divided into eight sections in accordance with the requirements in Attachment A of the Order. The report sections are described below:

- **Section 1.0: Introduction** – This section presents the purpose and scope of this document and describes the physical setting, geology and hydrogeology, facility history, land use, and corrective action objectives for soil, groundwater, and bank soil and sediment.
- **Section 2.0: Media Cleanup Levels and Constituents of Concern (COCs)** – This section summarizes the development of groundwater target media cleanup levels (TMCLs) and proposed final media cleanup level (FMCLs), identifies "modeled" soil concentrations for the protection of the soil-to-groundwater leaching pathway, and describes the evaluation process used to identify COCs and develop corresponding proposed FMCLs. Within this document, the term FMCLs refers to the proposed (or draft) FMCLs. When approved by USEPA, the proposed FMCLs will no longer be considered draft for corrective measures and will replace all previous cleanup levels and screening levels used at the site (with the exception of the current soil-to-groundwater screening level).
- **Section 3.0: Interim Measures and Site Changes** – This section presents a summary of physical changes completed at Plant 2 since the RFI including soil removal actions during construction projects, IMs, and site redevelopment; placement of soil and crushed concrete backfill; the electronics manufacturing facility (EMF), the DSOA, Southwest Bank Corrective Measure and JFOS; and groundwater IMs.

- **Section 4.0: Current Site Conditions** – This section describes current soil and groundwater conditions and presents figures showing areas of FMCL, leaching screening levels (leaching SLs), and FMCL exceedances for COCs. In addition to the Section 4.0 figures, Attachment S4B provides groundwater maps presenting DGI and more recent data for individual COCs within the seven DGI study areas.
- **Section 5.0: Evaluation of Remedial Technologies** – This section describes the technology screening process for soil and groundwater remediation at Plant 2. The supporting Attachment S5A presents additional detail on the rationale, screening tables, and evaluations including technology feasibility, technology groupings, and locations where the technologies are appropriate based on location-specific geochemistry and contaminant type, distribution, and concentration.
- **Section 6.0: Identification of Remediation Areas and Evaluation of Alternatives** – This section identifies remediation areas (RAs), assembles technologies into alternatives, and evaluates alternatives for each RA.
- **Section 7.0: Recommended Remedial Alternatives** – This section presents the proposed corrective measure for each RA.
- **Section 8.0: References** – This section contains a list of references cited in this document organized by topic.

1.3 Data and Remedial Technology Evaluation Process

In this report, analytical data for constituents from the seven Plant 2 study areas are first evaluated relative to their TMCLs to identify constituents of potential concern (COPCs). The COPCs are then evaluated further to develop site-specific proposed FMCLs that consider the site's physical, chemical, and geological conditions and engineering and institutional controls that will be maintained at the site. Constituents exceeding the FMCLs are considered COCs, and the locations where the COCs exceed FMCLs are identified as locations that require further evaluation for potential corrective measures. Locations that require soil or groundwater remediation are identified in Section 6.0, and remedial technologies potentially capable of achieving their respective FMCLs are selected for further evaluation.

Each remedial technology that warrants a more detailed evaluation, including those situations when only one remedy is proposed, is evaluated relative to the five standards listed in the Office of Solid Waste and Emergency Response (OSWER) Directive 9902.3-2a (USEPA 1994b).

1.4 Site Setting

Plant 2 is located on the east bank of the Duwamish Waterway in Seattle and Tukwila, Washington (Figure 1-1). Historically, Plant 2 has specialized in manufacturing aluminum alloy, steel alloy, and titanium alloy parts for airplanes. Plant 2 was built on farmland in the late 1930s and became a significant manufacturing facility during World War II. In recent years, the character of Plant 2 has shifted toward warehousing, research, and administration.

Plant 2 is bounded on the east by East Marginal Way South, a four-lane arterial; on the south by Jorgensen Forge, an active steel, aluminum, and specialty metals manufacturing facility; on the north by Slip 4 and Emerald Services, Inc.; and on the west by the Duwamish Waterway. The Duwamish Waterway is a federally maintained shipping channel of the Duwamish River. Slip 4

is an off-channel extension of the waterway. Plant 2 is served by both truck and rail, and is accessible from the waterway.

1.4.1 Physical Setting

A more detailed discussion of the physical setting of Plant 2 is included in Volume I of the CMS Report, which was originally submitted in the second quarter of 2015, revised to incorporate USEPA comments submitted to Boeing on November 29, 2016, and resubmitted in March 2017 (EPI 2017). Volume I of the CMS report was approved for incorporation into a revised draft of the full CMS report by USEPA on May 19, 2017. The following paragraphs are intended to be an overview of the information contained in that report.

Plant 2 is located in the central portion of the Duwamish Valley adjacent to the tidally-influenced Duwamish Waterway, as shown in Figure 1-1. The Duwamish Valley is bounded to the east by Beacon Hill, which rises to an elevation of 300 feet and separates the valley from the Lake Washington drainage basin. The western boundary of the Duwamish Valley is a topographic and hydrologic divide that separates the valley from the Puget Sound. The Duwamish Valley is part of the Duwamish Estuary Sub-Watershed, which is within the Green River Watershed.

The historical Duwamish River was dredged and realigned to form the current channel of the Duwamish Waterway. This realignment was completed in approximately 1918 and moved the river from its former location at the present day King County International Airport (KCIA) to its current location to the west of Plant 2 (Weston 1996). The alignment of the historical Duwamish River circa 1895 did not pass through Plant 2, except for Slip 4 and small areas along the current Duwamish Waterway in the North and 2-66 Areas. Industrial development of the area beginning in the 1930s resulted in pavement or buildings covering a large portion of Plant 2.

1.4.2 Regional Geology

The topographic divides that form the boundaries for the Duwamish Valley to the west and east are composed of sedimentary bedrock of Tertiary age overlain by Quaternary glacial deposits. The Duwamish Valley consists of recent sediments underlain and bounded by older Quaternary glacial deposits and, locally, Tertiary bedrock. The more recent near-surface sediments of the Duwamish Valley are set within the trough of the Duwamish Estuary, carved by glacial ice, and subsequently in-filled by river sediment. The lower boundary of that trough has been explored infrequently during deep subsurface borings, particularly in the southern half of the study area. The pattern exhibited by the subsurface data indicates that the trough lies roughly 200 feet below the current ground surface along the axis of the valley, generally becoming more shallow to the south and also towards the east and west valley walls. The boundary of these deposits is marked by bedrock to the east, or by very dense sediment that has been glacially overridden to the west (Booth and Herman 1998).

Above this boundary, the geologic history of the area suggests that a sequence of estuarine deposits, typically fine sands and silts with shells, progress into a complex interbedded river-dominated sequence of sand, silt, and gravel that marks the advance of the sedimentary wedge fed by the Osceola Mudflow and later deposits. The mudflow itself would have been very thin and subaqueous along the Duwamish Valley when first deposited; therefore, the chances of intersecting (and recognizing) that layer by drill cores is probably low. The upper part of the river-deposited sediment shows the classic signs of continued slow overbank deposition by fine sand and silt, colonization by marshland plants, and occasional erosion and refilling by coarser

sediment associated with the main channel of the migrating Duwamish River (Booth and Herman 1998).

The most recent phase of the valley's geologic history includes the filling of tideflats and floodplains, and the subsequent dredging of a straightened channel of the meandering Duwamish River. Completed between approximately 1913 and 1918 by the US Army Corps of Engineers (USACE) Duwamish Waterway District, the new channel is 4.5 miles in length south from the East and West Waterways. As a result of the waterway development, 12.5 miles of old river bed were abandoned. The excavated waterway material was used to fill the old channel areas and the lowlands above flood levels. Subsequent filling for land development purposes has resulted in a surficial layer of fill over most of the lower Duwamish Valley. The heterogeneous nature of fill materials can locally affect both infiltration characteristics and groundwater flow where the water table is below these fill materials. Because much of the thicker fills that occur below the water table are dredged from the Duwamish River, the silts and sands are difficult to distinguish from the native alluvium and have the same general hydrogeologic properties (Booth and Herman 1998).

1.4.3 Plant 2 Geology

The oldest (deepest) sediments encountered during the RFI and DGI consist of marine silt (the lower silt unit) deposited on the underlying glacial till unit. These two low-permeability deposits form an aquitard that isolates the shallow Duwamish Valley Aquifer from any deeper, potential drinking water, aquifers beneath Plant 2. Above the lower silt unit is a thick, water-bearing, coarsening-upward sequence consisting of interbedded sand and silty sand. A thin layer of fill material consisting of coarse sand with varying amounts of silt overlies the naturally-deposited sand that makes up the upper aquifer beneath Plant 2. The shallow portion of the upper aquifer consists of medium sand with varying amounts of silt. The upper aquifer also includes an approximate 2-foot-thick layer of brownish to greenish-gray to black silt and soft organic silt at depths typically ranging from approximately 4 to 11 feet below ground surface (bgs). This silt layer is present in many, but not all, boring logs throughout the facility, although it appears to vary in thickness and depth. A more detailed description of the regional and local geology at Plant 2, including a generalized cross-sectional diagram of the stratigraphy beneath Plant 2, is presented in Volume I of the CMS Report (EPI 2017).

1.4.4 Plant 2 Hydrogeology

For investigation purposes at Plant 2, the upper 30 feet of the of the Duwamish Valley Aquifer is referred to as the A-Level of the aquifer. The middle portion of the aquifer from 30 to 60 feet bgs is referred to as the B-Level of the aquifer. At approximately 60 feet bgs, the silt content increases in a gradational change that can be distinguished based on field observations (Weston 1996). The aquifer material below 60 feet bgs is referred to as the C-Level of the aquifer. At approximately 70 to 90 feet bgs, a distinctive marine silt layer with shell fragments is noted in boring logs from Plant 2, which represents the base of the C-Level of the aquifer. The contact between the silty sand and the marine silt is sharp and readily noted in the field. More detailed descriptions of Plant 2 hydrogeology are presented in the following sections and in Volume I of the CMS Report (EPI 2017).

Two major influences control much of the groundwater flow beneath Plant 2: tidal influences from the Duwamish Waterway, which is affected by tidal levels in Elliott Bay and Puget Sound; and direct infiltration of precipitation.

Recharge to the shallow aquifer is primarily from direct infiltration in areas of the valley that are not paved or covered by buildings. There is also some limited infiltration and groundwater flow from the bounding ridge to the east of Plant 2. Subsurface flow to valley aquifers from the adjacent ridges is expected to be uniform throughout the Duwamish Valley. Because Plant 2 is primarily paved or covered with buildings or building slabs and has an engineered stormwater conveyance system, direct recharge to the shallow aquifer beneath the facility is limited, with most runoff directed to storm drains leading to engineered swales and then to the Duwamish Waterway.

Recharge and discharge relationships reflect the role of groundwater flow patterns within the continuous water cycle. Recharge occurs where precipitation can infiltrate the ground surface and move downward to the water table. Once in the aquifer, groundwater flows from areas of higher hydraulic head to areas with lower hydraulic head. The hydraulic head of groundwater in the Duwamish Valley is less than in the surrounding ridges flanking the valley, but is higher than the net water level of the Duwamish Waterway.

Groundwater in the Duwamish Valley Aquifer ultimately discharges into the Duwamish Waterway because the waterway has lower hydraulic head than the Duwamish Valley and the ridges flanking the valley. The Duwamish Waterway serves as a long, linear groundwater sink along the axis of the valley, causing groundwater at Plant 2 to flow toward the waterway rather than down the valley northward toward Elliott Bay (Weston 1996).

1.4.4.1 Hydraulic Conductivity

The distinction between the shallower levels (A- and B-) and the deeper C-Level of the Duwamish Valley Aquifer is supported by increasing silt content and decreasing hydraulic conductivity with depth. The sand unit present in the A- and B-Levels is generally more permeable than the deeper silty sand unit present in the C-Level of the aquifer as summarized below:

- Hydraulic conductivity values in the A-Level and B-Level wells, based on multiple well aquifer test data and tracer studies, are generally 10^{-2} to 10^{-1} centimeters per second (cm/sec; 200 to 400 feet/day) with a value of 300 feet/day generally used for most calculations and comparisons.
- The hydraulic conductivity of the C-Level of the aquifer is generally 10^{-4} cm/sec, or approximately 3 feet/day, based on the mean hydraulic conductivity value for 10 slug tests performed in C-Level wells by GeoEngineers (three tests) and Roy F. Weston, Inc. (seven tests). No pumping test data exist for wells in the C-Level of the aquifer.

Vertical hydraulic conductivities in each unit are consistently three to four orders of magnitude less than horizontal hydraulic conductivities and are generally 10^{-5} cm/sec in A- and B-Level wells and 10^{-7} cm/sec in C-Level wells, indicating a high degree of anisotropy in all of the geologic units making up the A-, B-, and C-Levels of the Duwamish Valley Aquifer.

1.4.4.2 Groundwater Flow Rates

Groundwater flow at Plant 2 is primarily horizontal with a calculated average flow velocity of approximately 876 feet per year in the upper A-and B-Levels of the aquifer. This is based on a hydraulic conductivity of 300 feet/day, a horizontal gradient of 0.002, and an effective porosity of 0.25. The calculated average groundwater flow velocity for the C-Level of the aquifer is 13 feet per year based on a hydraulic conductivity of 3 feet/day, a horizontal gradient of 0.003, and an effective porosity of 0.25. The difference in groundwater flow rate is due primarily to difference in

hydraulic conductivity, which is two orders of magnitude lower in the C-Level of the aquifer. Horizontal hydraulic gradients continually change in tidally-influenced areas, especially in the A- and B-Levels in response to tidal fluctuation in the Duwamish Waterway.

1.4.4.3 Groundwater Seepage Rates

Groundwater flow directions temporarily reverse and flow inland during high tide in areas immediately adjacent to the Duwamish Waterway. This phenomenon is transient, localized along the waterway, and does not prevent the eventual discharge of groundwater to the Duwamish Waterway. Groundwater discharge rates from Plant 2 to the Duwamish Waterway have been calculated at approximately 676 gallons per minute (gpm). Most of the discharge (670 gpm) is from the A- and B-Levels of the aquifer. The discharge rate for the A- and B-Levels of the aquifer is based on a discharge seepage face area of 215,000 square feet (50 feet wide by 4,300 feet long, which includes the Plant 2 shoreline on the Duwamish Waterway and Slip 4), a hydraulic conductivity of 300 feet/day, and a horizontal groundwater gradient of 0.002. The discharge rate for the C-Level of the aquifer is based on a discharge seepage face of 30 feet deep by 4,300 feet long (which includes the Plant 2 shoreline on the Duwamish Waterway and Slip 4), an average hydraulic conductivity of 3 feet/day, and a horizontal groundwater gradient of 0.003.

1.4.4.4 Tidal Influence on Groundwater

Depth to groundwater at Plant 2 is generally within 10 to 12 feet of ground surface. Groundwater close to the waterway is strongly influenced by tidal fluctuations. Tidal efficiency (i.e., the ratio of water level fluctuation in monitoring wells divided by water level fluctuations in the waterway) diminishes with increasing distance from the waterway and is negligible (less than 1 percent) at approximately 800 to 1,000 feet from the waterway in the A-Level of the aquifer and approximately 600 feet from the waterway in the B- and C-Levels. Tidal efficiency of the C-Level has only been investigated at the south end of Plant 2 and appears to be like data from the B-Level of the aquifer.

1.4.4.5 Groundwater Salinity

Groundwater flow at Plant 2 is influenced by the presence of saline surface water present in the lower depths of the Duwamish Waterway. Following the initial dredging and realignment of the waterway in 1918, a lense of saline surface water extended back into the waterway and, driven by density differences, has intruded downward and laterally dispersed below the waterway into the adjacent aquifer. As a result of this saltwater intrusion, a “saline groundwater wedge” has formed beneath the waterway. The presence of brackish to saline water in the aquifer has been observed in monitoring wells adjacent to the waterway and in deep wells, as indicated by very high specific conductance measurements and extremely elevated concentrations of dissolved sodium, chloride, bromide, and total dissolved solids (Weston 1996). Saltwater intrusion has been well documented in other tidally-influenced aquifers, and the same processes are considered to apply in the aquifer underlying Plant 2.

The presence of a saline groundwater wedge beneath the Duwamish Waterway is predicted by the Ghyben-Herzberg relation (Herzberg 1901) and by Hubbert (1940), and is described in Volume I of the CMS Report (EPI 2017). The presence of the saline groundwater wedge affects the movement of fresh groundwater near the waterway with the saline groundwater wedge serving as a dense, stable mass that is in dynamic equilibrium with the surrounding, less saline and therefore less dense groundwater. The less dense, fresh groundwater that flows toward the waterway is forced to move upward over the denser saline groundwater wedge creating an

upward vertical groundwater gradient. Limited mixing between the saline and fresh groundwater would be expected and is generally observed along this interface.

The apparent stratification of the aquifer is not likely due to the intrusion of saltwater from the Duwamish Waterway. If that were the case, the position of the saltwater/freshwater interface would be closer to the waterway. The RFI Report presents the hypothesis that the saline groundwater found at depth away from the waterway is a remnant of connate water, which was marine water during glacial-era sedimentation and that has remained stratified at depth due to limited mixing with shallower groundwater (Weston 1996). Groundwater mixing may be limited by density differences between the deeper, more-saline water and the overlying freshwater and by the order of magnitude lower permeability of the C-Level portion of the aquifer relative to the A- and B-Levels. This hypothesis is supported by tritium analyses indicating that tritium was not detected in deeper C-Level groundwater samples. However, tritium was detected in the upper A- and B-Levels of the aquifer at levels approximately equal to levels of tritium detected in the Duwamish Waterway (Weston 1996). These studies suggest that the saline groundwater in the C-Level might be significantly older than the less saline groundwater found in the shallower A- and B-Levels of the aquifer.

The saline groundwater remains in the C-Level of the aquifer because groundwater mixing is limited by density differences between the deeper, more saline groundwater and the overlying fresh groundwater, and by a two orders of magnitude lower vertical hydraulic conductivity of the C-Level of the aquifer relative to the A- and B-Levels. Limited mixing between the B- and C-Levels of the aquifer occurs and results in brackish groundwater commonly noted in deeper intervals of the B-Level of the aquifer.

The combination of an upward vertical groundwater gradient and limited mixing between deeper saline groundwater and overlying fresh groundwater has likely limited impacts to deeper C-Level groundwater from surface and near-surface contaminant sources. In addition, the thick sequences of low permeability marine silt and glacial silt in the aquitard underlying the C-Level of the aquifer further limit the potential for impacts to deeper drinking water aquifers.

To summarize, salinity in the C-Level of the Duwamish Valley Aquifer is a natural consequence of several processes:

- The original depositional environment of the valley as a marine embayment ensured that the aquifer formed under a saline environment.
- The low volume of groundwater recharge from the adjacent uplands limits the amount of “flushing” with freshwater that can occur, especially at depth in the lower permeability C-Level of the aquifer.
- Recharge from direct infiltration of precipitation and from the limited discharge from the uplands would preferentially move through the more permeable A- and B-Levels of the aquifer to discharge into the river. As a result, the A- and B-Levels of the aquifer have more opportunity for freshwater recharge and flushing than the older, less permeable C-Level of the aquifer.
- Upward vertical gradient directions throughout much of the Duwamish Valley Aquifer, especially along the discharge zone at the Duwamish Waterway, further prevent dilution of deeper saline groundwater by infiltration of precipitation.

1.4.4.6 Iron and Manganese in Groundwater

Iron and manganese data are correlated in that wells with high iron concentrations also have high concentrations of manganese. Iron concentrations are significantly greater than the secondary Maximum Contaminant Level (MCL) of 0.3 milligrams per liter (mg/L) throughout all three depth levels of the aquifer. The same is true of manganese concentrations: manganese concentrations throughout all three depth levels of the aquifer are commonly significantly greater than its secondary MCL of 0.050 mg/L (Floyd|Snider and Aspect Consulting 2014). This correlation has been documented elsewhere throughout the Puget Sound (Turney 1986) and in studies focusing on the Duwamish Valley (City of Seattle and King County 2004). The authors of these reports note that reducing (anaerobic) geochemical conditions are caused by naturally organic-rich sediments, which cause iron and manganese to be desorbed from common and naturally-occurring iron and manganese minerals in soil and rocks; iron is especially common in clay soils, such as those found in the Puget Sound region (Woodward et al. 1995).

At Plant 2, oxygen demand is significant from the organic-rich sediments composing the A-Level of the aquifer, including the silt overbank deposit that represents the historical vegetated surface of the tide flat before the river was dredged. High natural oxygen demand coupled with restricted infiltration and vertical mixing creates limited opportunity for recharge of dissolved oxygen (DO) in the aquifer by infiltration of oxygenated rainwater throughout the predominantly paved area of Plant 2. However, in the unpaved habitat areas along the Duwamish Waterway, infiltration and tidal fluctuations create a different geochemical environment.

A-Level groundwater in areas that are in the tidal pumping zone close to the Duwamish Waterway experiences significant tidal fluctuations of several feet. The cycle of vertical groundwater movement and infiltration of oxygenated rainwater in the unpaved habitat areas locally oxygenates shallow groundwater as it approaches the waterway. Rising tides cause groundwater to temporarily rise into air-filled pore spaces in the aquifer matrix becoming oxygenated. This oxygenated groundwater drains back the A-Level of the aquifer on a falling tide. Tidal fluctuations are relatively significant within approximately 100 to 200 feet of the Duwamish Waterway, as noted in CMS Volume I (EPI 2017).

As groundwater containing any remaining dissolved iron and manganese approaches the Duwamish Waterway, physical mixing of surface water and groundwater occurs in the bank storage zone adjacent to the waterway. This interaction of relatively oxygen depleted groundwater with oxygenated Duwamish Waterway water results in oxidation of constituents (particularly iron, and manganese), and results in precipitation of insoluble minerals (e.g., ferric hydroxide). Such precipitation would be expected to remove other dissolved metals (such as arsenic, copper, and lead) from solution by co-precipitation and loss of other metals due to sorption to the hydroxide mineral surface (EPI 2017). The near-shore tidal influence creates an aerobic environment that is not present at locations farther from the waterway or deeper in the aquifer (Floyd|Snider and Aspect Consulting 2014).

1.5 Facility Layout and Regulatory History

Plant 2 occupies an area of approximately 107 acres and is topographically flat land that was, until recent demolition and redevelopment activities, covered by buildings, concrete slabs, and paved yards. Most demolished buildings were (and the few remaining buildings are) slab on grade with underground utilities.

The western and northern edges of Plant 2 abut the Duwamish Waterway. The northern edge abuts Slip 4, a relatively shallow extension of the waterway. The western edge abuts the main channel of the waterway. A public road, 16th Avenue South, crosses Plant 2 dividing it into northern and southern sections, and connects to the South Park Bridge, one of the major bridges across the Duwamish Waterway. The area beneath the eastern supports for the bridge is paved industrial land and this land use continues north to approximately 900 feet to the north side of the 2-10 Building. Beyond the 2-10 Building are the Northern Habitat Area and a long expanse of unpaved shoreline that parallels and abuts the habitat area, and wraps around and abuts Slip 4 (Figure 1-2).

In the unpaved areas, the top of the bank of the Duwamish Waterway is considered the beginning of the uplands area. In the paved area between the 2-10 Building and the bridge, the uplands area is the edge of pavement, which is often piling- or bulkhead-supported. The 2-10 Building is piling-supported and extends over the waterway; the demarcation between the uplands and sediment beneath the 2-10 Building is the first retaining board on the waterway side of the main bulkhead (Figure 1-3 contains a cross-section showing this in more detail).

South of the bridge, the shoreline has been rebuilt to support the Southern Habitat Area. Throughout this area, the uplands begin at the top of the bank and nominally include the riparian buffer and plantings for the habitat area. The very southern section of the western boundary includes the historical 2-66 sheetpile structure which is covered with pavement. This paved section of the site is part of the paved industrial area.

The RFI identified RCRA units comprised of Solid Waste Management Units (SWMUs), Areas of Concern (AOCs), and Other Areas (OAs) where solid or hazardous waste is or was managed at Plant 2 (Weston 1998). Table 1-2 presents RCRA units including SWMUs, AOC, and OAs evaluated as part of the CMS process.

During the RFI and early stages of the CMS process, environmental impacts at Plant 2 were evaluated following RCRA guidance using a unit-by-unit approach. During preparation of the CMS Work Plans, the unit-by-unit approach was found to be inadequate for characterization of groundwater impacts because of soil/groundwater interactions and because groundwater plumes tend to move, commingle, and lose their associations with any particular unit.

During the DGI process, Plant 2 was divided into seven “study areas” to facilitate investigation of groundwater contamination and its relationship with soil contamination. These areas represent “slices” of the facility running parallel to groundwater flow lines so that plumes are contained within the slices. A summary of each of the seven study areas at Plant 2 is presented from south to north in the following sections. Figures 1-4 through 1-10 show the location of RCRA units and other features within the CMS areas at Plant 2. A complete description and history of each study area and associated RCRA units are provided in the area-specific DGI Work Plans (EPI et al. 2005a, 2005b; and EPI and Golder 2006, 2008a, 2008b, 2009a, and 2009c).

For the purposes of the CMS, both the unit-by-unit approach used prior to 2005, and the study areas approach used in the DGI process have been replaced with the development of specific RAs in Section 6.0 with remedial alternatives to address COCs for each RA. To ease the reader’s transition from earlier CMS volumes to this document, the DGI study areas are described below.

1.5.1 South Yard Area

The southern-most portion of Plant 2, referred to as the South Yard Area, consists of approximately 12 acres (Figure 1-4). It extends from the northern exterior wall of Buildings 2-80, 2-81, and 2-85, south to the Jorgensen Forge property and railroad line, east to East Marginal Way South, and west to the boundary line of Area 2-66. The South Yard Area contains Buildings 2-80/81, 2-83, 2-84, 2-85, 2-88, 2-117, and 2-126 and 18 RCRA units (Table 1-2).

1.5.2 2-60s Area

The area north of the South Yard of Plant 2, referred to as the 2-60s Area, consists of approximately 12 acres (Figure 1-5). The 2-60s Area is bordered by East Marginal Way South to the east, the South Yard Area to the south, the 2-66 Area to the west, and the 2-40s Area to the north. The 2-60s Area was included in the 2010-2012 demolition and redevelopment project and is currently devoid of buildings and covered by asphalt except for the 2-127 Building. Many buildings were previously located in the 2-60s Area including Buildings 2-48, 2-51, 2-57, 2-61, 2-62, 2-63, 2-64, 2-65, and part of Building 2-108. There are 14 RCRA units located in the 2-60s Area as presented in Table 1-2 and Figure 1-5.

1.5.3 2-66 Area

The 2-66 Area is located southwest of the 2-60s and South Yard areas of Plant 2 and consists of approximately 4 acres (Figure 1-6). The 2-66 Area is bordered on the east by the 2-60s Area and the South Yard Area; Jorgensen Forge lies to the southeast, the Duwamish Waterway to the west, and the 2-40s Area to the north. The 2-66 Area contained major portions of Building 2-49 and the former Building 2-66 Slab prior to the 2010-2012 demolition and redevelopment project. The 2-66 Area also included the Southwest Bank Corrective Measure area, which is being managed separately as part of the DSOA. The Seattle City Light (SCL) Transformer Investigation area (OA 11) was addressed separately from the CMS as an IM in fall 2016. The 2-66 Area includes the 2-66 Sheetpile containment structure which was constructed in 1994 to contain soil and groundwater with elevated concentrations of chlorinated volatile organic compounds (cVOCs) and prevent migration and transport of contaminants through the subsurface. OA 19 (Building 2-49 Stretch Press Pit and Outfall No. 12) is located within the DSOA and Southwest Bank Corrective Measure area. The nine RCRA units located in the 2-66 Area are presented in Table 1-2 and Figure 1-6.

1.5.4 2-40s Area

The area north of the South Yard, 2-60s, and 2-66 Areas of Plant 2, referred to as the 2-40s Area, consists of approximately 30 acres and 19 RCRA units (Figure 1-7). The 2-40s Area is bordered by the 2-60s and 2-66 Areas to the south, the 2-31 Area to the north, the Duwamish Waterway to the west, and East Marginal Way South to the east. The 2-40s Area contained Buildings 2-40, 2-41, 2-44, 2-45, and a portion of Building 2-49, which were all demolished in 2010-2011. Prior to the completion of the DSOA and Southwest Bank Corrective Measure in 2013, several RCRA units associated with the 2-40s building complex existed on both sides of a rear bulkhead wall. The buildings were demolished, the rear bulkhead wall was removed, and the footprint of the RCRA units within what became the Southern Habitat Area was remediated as part of the DSOA and Southwest Bank Corrective Measure. The RCRA units associated with the DSOA Corrective Measure and habitat project included SWMU 2-41.35, Quench Tanks, SWMU 2-41.36, Underflow Flume, AOC 2-41.29, TCE Degreaser, and Outfall Areas 14, 16, and 23 (OAs 20, 22.A and 22.B). In some cases, a section of the unit continued into the uplands beyond the corrective measure.

Where this exists, it is evaluated as part of this document. The 20 RCRA units located in the 2-40s Area are presented in Table 1-2 and Figure 1-7.

1.5.5 2-31 Area

The 2-31 Area of Plant 2 consists of approximately 10 acres and is bordered on the east by East Marginal Way South, on the south by the 2-40s Area, on the west by the Duwamish Waterway, and on the north by the 2-10 Area (Figure 1-8). The 2-31 Area is separated from the 2-10 Area by 16th Avenue South. The 2-31 Area contains Buildings 2-22, 2-25, 2-28, 2-31, and 2-36. The nine RCRA units located in the 2-31 Area are presented in Table 1-2 and Figure 1-8.

1.5.6 2-10 Area

The 2-10 Area of Plant 2 consists of approximately 23 acres and is bordered on the east by East Marginal Way South, on the south by the 2-31 Area, on the west by the Duwamish Waterway, and on the north by the North Area (Figure 1-9). The 2-10 and 2-31 Areas are separated by 16th Avenue South. The 2-10 Area contains Buildings 2-10, 2-15, 2-120, and 2-123 and the concrete foundation for former Building 2-09. Several of the RCRA units present in the area are referenced to these buildings.

The western edge of the 2-10 Area abuts the Duwamish Waterway and includes a portion of the 2-10 underbuilding and adjacent areas generally to the north and south of the building. The 2-10 Building's westernmost 50 feet of concrete floor extends beyond the building's slab foundation and is pile-supported. The first retaining board toward the waterway from the main bulkhead, associated with the piles supporting building column line D, identifies the boundary between the uplands CMS area and the Duwamish Waterway shoreline (Figure 1-3).

However, the DSOA SOB did not address the underbuilding area from the western face of the 2-10 Building east to the retaining board. That area will be further addressed in Section 1.7.3.

Several RCRA units are located along the western portion of the 2-10 Building including AOC 2-10.1 AB (Hydraulic Stamp Machine Sumps), SWMU 2-10.4 (Zyglo Penetrant Spray Booth), SWMU 2-10.8 (Anodic and Alodine Tank/Lines), and OA 8 (Building 2-09 Chrome Waste Tank [SWMU 2-09.2]). These RCRA units do not extend into (or over) the Duwamish Waterway with one exception: a portion of SWMU 2-10.4 (Zyglo Penetrant Spray Booth) extends over the waterway. The spray booths were located on top of the concrete floor in the pile-supported area, but did not have foundations penetrating the concrete slab. This unit and the other units along the western edge of the 2-10 Building will be managed as part of the Uplands CMS and not as part of the DSOA.

The 22 RCRA units located in the 2-10 Area are presented in Table 1-2 and Figure 1-9.

1.5.7 North Area

The area northwest of the 2-10 Area of Plant 2, referred to as the North Area, consists of approximately 19 acres. The North Area is bordered on the north by Emerald Services Inc. and on the southeast by the 2-10 Area (Figure 1-10). The southwestern and northwestern edges of the North Area abut the Duwamish Waterway and Slip 4, respectively.

The North Area contains Buildings 2-122, 2-124, the wastewater containment structure, and extensive grounds devoted to public access and stormwater controls (Figure 1-10).

Building 2-122 was constructed in 1992 and houses the Integrated Aircraft Systems Laboratory. The wastewater containment structure and the 2-124 Building were built in 2006 to support this laboratory. The one RCRA unit located in the North Area is presented in Table 1-2 and Figure 1-10.

1.6 Land Use

King County has zoned the paved industrial area of Plant 2 as industrial as defined in the Chapter 70.105D Revised Code of Washington (RCW) and King County's zoning regulations. It is anticipated that the paved industrial area will remain in industrial use and will not be used for residential purposes, childcare facilities, K-12 public or private schools, grazing of animals, or growing food crops. The unpaved shoreline area of Plant 2 will be remediated to cleanup levels that are based on unrestricted land use and protection of sediments in the Lower Duwamish Waterway; no land use restrictions are anticipated to be placed on the unpaved shoreline area.

1.7 Corrective Action Objectives

Corrective action objectives (CAOs) are media-specific goals that will be implemented during the remedy evaluation and selection process described in this document.

1.7.1 Corrective Action Objectives for Soil

Current land use within the majority of Plant 2 is industrial and environmental covenants will be used to ensure this land use remains the same. The riparian shorelines as part of the Northern and Southern Habitat Areas are not intended to be open for public access. Soil CAOs include the following:

- Protect Plant 2 office workers, industrial workers, construction workers, and authorized visitors from ingesting, contacting, or inhaling soil COCs that result in an estimated excess cancer risk exceeding 1×10^{-4} or a chronic hazard quotient exceeding 1.0. These levels are defined by the RCRA Order; however, FMCLs proposed in this document will be based on the 1.0×10^{-5} risk level, rather than the less stringent 1.0×10^{-4} level, to also comply with the Model Toxics Control Act (MTCA).
- Prevent erosion of shoreline soils into the Duwamish Waterway to protect the DSOA sediment remedy proposed in the *Alternative Corrective Measures Evaluation Report* (ACMER; AMEC and Floyd|Snider 2010), which includes protection of human health and the environment.
- Prevent soil from leaching COCs into groundwater at concentrations that would result in groundwater exceedances in the network of shoreline monitoring wells used to assess groundwater quality; these wells are located as near as reasonably practicable, given access limitations, to where groundwater discharges into the Duwamish Waterway, generally within approximately 40 to 170 feet of the waterway.

1.7.2 Corrective Action Objectives for Groundwater

The maximum beneficial use of groundwater at Plant 2 is discharge into the Duwamish Waterway. The following groundwater CAOs are not based on human consumption of groundwater, but rather are based on surface water criteria for protection of aquatic species and human health, based on the consumption of fish and shellfish:

- Ensure that groundwater discharging into the Duwamish Waterway from Plant 2 is protective of the aquatic and benthic biota in the Duwamish Waterway. This is accomplished in Section 2.0 by developing groundwater FMCLs that are protective of surface water quality for aquatic species. These FMCLs are intended to be applied at the point of compliance (POC), which are well locations as close as practical to where groundwater discharges into the waterway.
- Ensure that groundwater discharging into the Duwamish Waterway from Plant 2 is protective of human health based on the consumption of fish and shellfish from the Lower Duwamish Waterway. This is accomplished in Section 2.0 by developing groundwater FMCLs that are protective of surface water quality for human consumption. These FMCLs are intended to be applied where groundwater discharges into the waterway.
- Ensure that the DSOA sediment remedy is not re-contaminated by groundwater discharging through the remedy. Estimated groundwater discharge to the Duwamish and other details necessary to perform the evaluation were presented in Appendix H of the CMS for the DSOA and Southwest Bank (AMEC and Floyd|Snider 2011b). Appendix H concluded that current concentrations of groundwater are protective of the sediment remedy; therefore, no further discussion is presented in this document.

The above considerations apply to groundwater at the POC in close proximity to where groundwater discharges into the waterway; two additional considerations apply to groundwater throughout the site:

- Prevent human consumption of Plant 2 groundwater (consistent with the designation of the aquifer). Since the groundwater is not potable at Plant 2 due to naturally occurring conditions as outlined in Section 4.0 of CMS Volume I (EPI 2017), this will be accomplished by including a prohibition on groundwater use in the environmental covenant.
- Protect on-site workers from indoor air concentrations of COCs coming from volatilization of groundwater that results in an excess cancer risk exceeding 1 x 10-5 or a chronic hazard quotient exceeding 1.0.

1.7.3 Corrective Action Objectives for Bank Soil and Bank Sediment

Bank soil and sediment extend from the top of the bank to the toe of the slope. The top of the bank is approximately 18 feet above mean lower low water (MLLW)[3] along most of the shoreline. The bank separates the uplands at Plant 2 from the Lower Duwamish Waterway. Some areas of the bank are habitat areas, others are relatively steep and rip-rapped slopes, and one section lies beneath the 2-10 Building, which is built over pilings in the bank. The CAOs for bank soil and sediment include the following:

- Protect aquatic species from COCs at concentrations that would pose unacceptable risks to their health.

[3] MLLW is a common datum used for projects in Puget Sound. 0-feet MLLW (Epoch 1983-2001 for Elliott Bay and the Lower Duwamish) is equivalent to NAVD88 - 2.346 feet or to National Geodetic Vertical Datum (NGVD; 1929) 29 – 5.92 feet.

- Protect aquatic species from COCs at concentrations that would pose unacceptable risks to human health through the consumption of the aquatic species.
- Protect the DSOA Corrective Measure from recontamination by COCs at unacceptable risk levels by the erosion of shoreline banks.

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2.0 MEDIA CLEANUP LEVELS AND CONSTITUENTS OF CONCERN

This section presents the FMCLs for Plant 2 and discusses the overall data quality and availability.

2.1 Overview Media Cleanup Levels

Corrective actions conducted at RCRA sites must be protective of human health and environmental receptors, and must consider state and federal criteria protective of all exposure pathways that may be completed for each type of impacted media at the site. Media cleanup levels serve this purpose at Plant 2. Two types of media cleanup levels have been developed for Plant 2: TMCLs and FMCLs.

A TMCL is a target concentration for a specific hazardous constituent in a particular medium (e.g., soil, groundwater, or indoor air) combined with a POC where this concentration should be met. The POC for Plant 2 under the RCRA Order is the Duwamish Waterway; the POC for the EMF groundwater plume administered under CERCLA Order is groundwater itself. This definition meets both the requirements of the Order and MTCA. Under the Order, a preference is made for promulgated criteria. If no promulgated criteria exist *(*or if promulgated criteria do not address all potential exposure pathways for a specific constituent or medium), then additional human health or ecological risk-based criteria must be developed. For a specific medium, more than one exposure pathway often exists; this results in multiple promulgated criteria and/or risk-based criteria for each constituent that must be considered in the development of TMCLs. TMCLs are generic in that they do not consider site-specific physical factors (for example, groundwater conditions that influence attenuation) or engineering/ institutional controls, such as the industrial nature of the site.

Several iterations of cleanup levels have been used at Plant 2 since the Order was issued. In 1999, the RFI process developed preliminary media cleanup levels (PMCLs) to provide goals for IMs that were to be conducted prior to the formal development and approval of TMCLs. In 2004, PMCLs were updated by incorporating a number of regulatory and toxicity factor changes that occurred between 1999 and 2004; the updated PMCLs were referred to as Screening Levels. Screening levels were used from 2004 to 2010 in support of the DGI process. In 2011, TMCLs were developed in the *Target Media Cleanup Levels Technical Memorandum* (Boeing 2011; TMCL Tech Memo) for each of the many constituents of interest identified by USEPA for each medium. Constituents of interest were selected based on sampling data, historical operations, and other factors. The TMCL Tech Memo describes details of the TMCL development process and the underlying assumptions made in the development of the TMCLs for Plant 2. In 2011, the TMCLs presented in the TMCL Tech Memo were approved by USEPA and replaced the PMCLs and 2004 SLs for the site.

For clarity, the TMCL Tech Memo presents TMCLs for the various constituent, medium, pathway, and POC combinations relevant to future corrective measures at Plant 2. The soil, groundwater, sediment, and indoor air data for Plant 2 were screened against the TMCLs (Attachment B of TMCL Tech Memo) to establish a list of COPCs; then called COCs that were carried forward for further consideration in this document.

Since the approval of the TMCL Tech Memo, toxicity factors and chemical-specific properties, including partitioning factors, have changed for many COPCs identified in the TMCL Tech Memo. In June 2015, USEPA published updated Federal Ambient Water Quality Criteria for protection of human health. In November 2016, USEPA issued a partial approval and partial disapproval of

human health criteria that Washington State submitted to USEPA; this resulted in a new set of Clean Water Act-effective federal human health criteria applicable to Washington (40 Code of Federal Regulations [CFR] 131.45). Additionally, natural background conditions in groundwater throughout the Duwamish Valley have been further defined, and several typographical or calculation errors were noted in the TMCL Tech Memo and in the October 2014 draft of the Uplands CMS Report. These and other sources of new information warranting revision of TMCLs are documented in Attachment S2A. Throughout the remainder of this document, the term TMCLs will refer to the 2011 TMCLs as revised for the reasons described above and in more detail in Attachment S2A. The TMCLs (as revised) for Plant 2 COPCs in groundwater and soil are included in Tables 2-2 and 2-5 of this document. Revisions to TMCLs for Plant 2 COPCs in indoor air are described in Attachment S2A.

Though TMCLs were revised for constituents that were not retained as COPCs, Boeing reviewed Plant 2 soil, groundwater, and ambient air data and determined that it was not appropriate to modify the current list of COPCs previously identified for the site, as the detected results were still below the frequency of exceedance thresholds used in Appendix B of the TMCL Tech Memo for identification of COPCs. TMCLs represent the most conservative cleanup levels that could be applied to any given medium at the site, and are often protective of exposure scenarios that would not occur at Plant 2 due to current and future land use restrictions, institutional controls, and other factors. FMCLs are similar to TMCLs, in that they are developed for each media (soil, groundwater, and ambient air) using the same equations and toxicity factors as the TMCLs, but are designed to account for site--specific transport and exposure limitations to humans and ecological receptors. Proposed FMCLs have been developed for each of the respective media for the site COPCs. When approved by USEPA, the proposed FMCLs will no longer be considered draft for corrective measures and will replace all previous cleanup levels and screening levels used at the site (with the exception of the current soil-to-groundwater screening level). Henceforth with the use of the acronym FMCL it will be implicit that the FMCL is proposed under this document. Similar to the identification of COPCs, COCs will be determined by comparing sampling results representative of current conditions to the FMCLs.

IMs and extensive site redevelopment have removed a substantial volume of impacted soil since the TMCL Tech Memo was approved in 2011. Therefore, some of the constituents that were identified as COPCs in the TMCL Tech Memo have already been addressed by these actions; i.e., they do not meet the criteria to become COCs or remain COPCs for Plant 2, and are not carried forward in this document when current soil, groundwater, and indoor air conditions are evaluated. Table 2-2 summarizes groundwater TMCLs and FMCLs. Detailed frequency of exceedance information for groundwater COPCs relative to the FMCLs is provided in Table 2-3; Table 2-4 summarizes groundwater FMCLs and COCs. Table 2-5 summarizes soil TMCLs, FMCLs, and leaching SLs; frequency of exceedance information for soil COPCs relative to FMCLs and leaching SLs is provided in Tables 2-6 through 2-9. Table 2-10 summarizes the COC status of each of the soil and groundwater COPCs, based on soil and groundwater datasets developed in 2014 and the revised TMCLs/FMCLs. Because the dataset used to identify COCs in soil and groundwater in Section 2.0 tables was generated in 2014, recent IMs and redevelopment actions targeting these sometimes have the effect of reducing the maximum detected concentration and exceedance factors reported in later sections of the report for Plant 2 COCs. Any apparent inconsistencies between Section 2.0 frequency of exceedance tables and later presentations of data in Section 4.0 and 6.0 are intentional, as the use of more current data is appropriate to use when describing current conditions and remedial alternatives.

Current data indicate that indoor air concentrations are below the FMCLs for each of the constituents that were identified as COPCs in the TMCL Tech Memo. In December of 2009 indoor air samples were collected and analyzed to validate the air exposure pathway relative to 2009 screening levels for the 2-10 Building. The 2-10 Building indoor air results are described in Volume IX Attachment E Report on Vapor Intrusion Sampling Building 2-10 (May 2010), which were reviewed to confirm indoor air data is not a medium of concern at Plant 2.

2.2 Overall Data Quality and Usability

Data collection and evaluation included in this document has been conducted under work plans and Quality Assurance Project Plans (QAPPs) as appropriate. All data were validated to a level necessary to determine the data quality and whether data quality objectives (DQOs) established in the various work plans were met. In the course of numerous data collection efforts, over 99 percent of all data collected in support of the CMS has been determined to be acceptable and meets the DQOs established for the respective work plans.

In evaluating the data for use in this document, several special considerations arose related to data quality and analytical methods; these considerations affect how data are used to evaluate whether a constituent is a COC, and whether there is need for corrective measures. These issues are discussed in the following subsections.

Following approval of Volume X of the CMS, Boeing will create and submit a new QAPP describing current analytical methods and sampling procedures to be used in future monitoring events to ensure future data is of sufficient quality for compliance with the FMCLs.

2.2.1 Method Evolution

To support the CMS efforts, data have been collected for more than 20 years using current accepted and USEPA-approved field and laboratory analytical methods. With changes in analytical methodologies over the years, precision and sensitivity of analytical measurements has improved, resulting in more recent data being generally of higher quality than older data. The increase in precision often reduces the value of older data, which is less descriptive of actual site conditions than data collected by newer, more precise methods.

2.2.1.1 TPH Method Changes

The analysis of petroleum hydrocarbons has gone through a number of fairly substantial method and reporting changes. The table below is a “map” that presents how regulatory standards group total petroleum hydrocarbons (TPH) into different product types for regulation in the first column; the second column lists the methods used at Plant 2 to generate concentrations that should be compared to those standards; and the last of column lists specific “products” that fall into that “standard.” The more modern Northwest TPH (NWTPH) methods are the best match to the regulatory standards used for the TMCLs and FMCLs.

Any future data collection for TPH will use NWTPH methods, rather than the older TPH methods. If new methods are developed in the future, they may be used only if they identify TPH fractions in a way that is consistent with the TPH FMCLs identified in this document.

TPH Reference Table Showing the Appropriate Regulatory Standard for Each Product Type

Regulatory Standard	Method	Quantified as
TPH as gasoline (benzene present >0.1%)	USEPA 8015M NWTPH--HCID NWTPH--G	Gasoline Gasoline-range hydrocarbons GRPH (gasoline range petroleum hydrocarbons)
TPH as aged gasoline (benzene present at <0.1%)	USEPA 8015M NWTPH--HCID NWTPH-G	Aged gasoline White gas Aviation gas Mineral Spirits Gasoline-range hydrocarbons GRPH (gasoline range petroleum hydrocarbons)
TPH as Diesel No. 2	USEPA 8015M NWTPH--HCID NWTPH-D or -Dx	Kerosene Diesel No. 1 Diesel No. 2 Total TPH by 8015M Diesel-range hydrocarbons DRPH (diesel range petroleum hydrocarbons)
TPH as Motor Oil	USEPA 8015M NWTPH--HCID NWTPH-D or -Dx	All oils (motor, hydraulic, heavy, etc.) Total TPH by “Oil and Grease” Oil-range hydrocarbons MoRPH (Motor oil range petroleum hydrocarbons) Bunker C Residual

2.2.1.2 Salinity Interferences with Metals Analyses in Water Samples

The current methods used for most metals analyses in the shoreline monitoring program are USEPA Method 6010B, which uses inductively coupled plasma atomic emission spectrometry (ICP-AES) and/or USEPA Method 200.8, which uses inductively coupled plasma mass spectrometry (ICP-MS). These analytical methods are prone to a positive interference caused by the presence of salinity for the following metals at low micrograms per liter (µg/L) concentrations: arsenic, selenium, copper, cobalt, chromium, nickel, vanadium, and zinc. While each of the interferences affect results in slightly different ways, they are all caused by the formation in the plasma of complexes with the sodium and chloride in seawater; these complexes then interfere, commonly as false positives, with the quantification of the metals. The use of normal ICP-AES and ICP-MS for saline water analysis can commonly lead to false positive results, some of which can be significantly greater than the true metals concentrations in the sample.

Following coordination with USEPA to address this technical aberration, Boeing began analyzing arsenic and selenium by both the borohydride method and the standard ICP/MS method in samples from C-Level wells in 2003. This work indicated improved analytical accuracy using the borohydride method; however, the borohydride method is only applicable for arsenic and selenium, leaving potentially biased data for other metal constituents that may be affected by the

saline groundwater matrix. Based on the borohydride method data collected since 2003, selenium was eliminated as a COC at Plant 2.

Since 2003, analytical methods used to mitigate saline matrix interferences have improved significantly and in 2011, Boeing began using USEPA Method 200.8 by inductively coupled plasma dynamic reaction cell mass spectrometry (ICP-DRC-MS) for all metals analyses except for chromium (VI) and mercury. The change was made because laboratories were producing more accurate reporting, due to ICP-MS methods that indicated definite positive biases/interferences for several metals, including copper, cadmium, selenium, and zinc. With the addition of the dynamic reaction cell, the interfering components in seawater (especially sodium and chloride) are no longer reaching the MS detector. The ICP-DRC-MS technology corrects for matrix interferences within the instrument itself and provides more accurate concentrations for metals; they are now able to obtain reporting limits (RLs) that are lower than the TMCLs.

This improved analytical method was used in post-DGI data from the shoreline monitoring program beginning in February 2011 and continuing through 2016, and confirms that saline matrix interference caused false positive FMCL exceedances for much of the nickel data. Additional rounds of groundwater sampling data were collected using the improved analytical method for nickel. As a result of these data, nickel remains a pending COC only at location PL2-621A; data collected at other locations demonstrate that nickel is in compliance with the FMCL at all other locations. More information about the current dataset illustrating that nickel is not a COC for any location except for PL2-621A is provided in Attachment S2B.

In 2011, Boeing also changed the method of analysis for chromium (VI) to the modified USEPA Method 7199 via ion chromatography inductively coupled plasma mass spectrometry (IC-ICP-MS). The change in analytical method was accepted by USEPA with approval of the document *Modification to CMS Phase Sediment Cap Impact Evaluation Monitoring Plan* (EPI 2011a). The data collected from the improved methods since 2003 were sufficient to eliminate several metals at the time of the 2011 TMCL Tech Memo, including selenium, vanadium, and chromium (VI).

Data based on the analytical changes implemented in 2011 are still being gathered for other metals that were identified as COPCs. Therefore, Table 2-1 defines a number of short-term sampling actions for COPCs that are not believed to be COCs at Plant 2 for reasons noted above. Additional rounds of data will be collected using the ICP-DRC-MS method, to gather an adequate amount of data of sufficient quality to determine whether these metals should be retained as COCs.

2.2.1.3 Cyanide Methods

Cyanide analyses at Plant 2 have evolved from total cyanide analysis (which includes all forms of cyanide and is the most conservative analysis) during the early DGI work to weak acid dissociable (WAD) cyanide analysis during later DGI events. This WAD cyanide analysis is a method that quantifies only free cyanide and weakly to moderately strongly complexed cyanide. More recent technical evaluations documented in the development of TMCLs indicate that free cyanide is the appropriate form of cyanide for comparison to the groundwater FMCL, which is based on the toxicity of free cyanide. Free cyanide must be analyzed using a free cyanide analysis method. Free cyanide was not quantified specifically during the DGI; therefore, the more inclusive total and WAD cyanide results were necessarily compared to the free cyanide TMCL during the analysis of groundwater data to determine COPCs in the TMCL Tech Memo.

Because of this data gap, cyanide was retained as a COPC at three locations downgradient or closely cross-gradient of areas with previous exceedances for total or WAD cyanide: PL2-615A, PL2-619A, and PL2-619B. Short-term groundwater monitoring of these three wells using the free cyanide method will provide an adequate amount of data of sufficient quality to determine whether free cyanide should be retained as a COC. More information is provided in Attachment S2B.

2.2.1.4 Total Polychlorinated Biphenyls

Total PCB results are analyzed in Plant 2 groundwater using USEPA Method 8082, which quantifies PCBs as Aroclors. Because of increased awareness of risks associated with PCBs even at low levels, laboratories have significantly improved the RLs that can be achieved with this method. However, the method is still incapable of achieving RLs that are less than the total PCBs TMCL. Though higher sensitivity methods are available for total PCBs, uncertainties remain with respect to how data collected with high sensitivity methods should be evaluated and used. Boeing and USEPA have reached an agreement to continue using USEPA Method 8082 for PCB analysis in groundwater, recognizing the need to adopt a more sensitive method for PCB analysis in the future. More information is provided in Attachment S2D.

2.2.1.5 Naphthalene and Trichlorobenzenes

Some chemicals are included on both the USEPA Method 8260 list for volatile organic compounds (VOCs) and the USEPA Method 8270 list for semi-volatile organic compounds (SVOCs). Naphthalene and the trichlorobenzenes are good examples of this, and commonly resulted in two results for the same constituent. The following rules were used to handle the data: 1) if detected, the highest detection was retained for the sample and the other result rejected; and 2) if not detected, the lower detection limit was retained for the sample and the other result rejected. Both results, however, are in the site RCRA database for a complete record.

2.2.2 Direct Push Probe Groundwater Samples

The collection of groundwater samples using a direct-push probe rig was a cost-effective way to collect samples to define the extent of groundwater contaminants during DGI. However, due to the very low FMCLs for groundwater, the samples collected using a direct push method were prone to false positives and high bias due to the entrainment of soil particles in the sample. For this reason, USEPA determined that groundwater samples from push probes were not of sufficient quality to determine COCs or to measure compliance, but were of sufficient quality to define the nature and extent of groundwater contamination. In this latter use, the false positives or biased high samples result in an overestimation of the extent of a known groundwater exceedance area, and any problem caused by the overestimation could be contained by the placement of compliance monitoring wells as part of the corrective measure. However, probe groundwater data could not be used to determine that a constituent with no exceedances in groundwater monitoring wells would become a groundwater COC. The USEPA's determination resulted in aluminum being eliminated as a groundwater COC; details regarding why this decision was considered appropriate are contained in Attachment S2B.

The use of probe data has also led to an isolated data gap for arsenic in well PL2-612AR, where groundwater discharges to Slip 4 and which has not historically been part of the shoreline monitoring well network. This data gap is identified in Table 2-1, which identifies short-term monitoring requirements designed to address data gaps that are typically caused by an insufficient number of samples of appropriate data quality at particular locations. Data quality

considerations and associated monitoring requirements at this location are presented in Attachment S2B.

2.2.3 Potential Blank Contamination Causing BEHP Exceedances

Bis(2-ethylhexyl)phthalate (BEHP) is a widely used plasticizer that is both a common laboratory contaminant and a common environmental contaminant. At Plant 2, BEHP is present in groundwater at concentrations above its TMCL/FMCL[4] only in analyses from 2008. At that time, USEPA asked that BEHP be analyzed in two rounds of shoreline monitoring. This was done in August 2007 and February 2008. BEHP was not detected in samples from any of the shoreline monitoring wells during the August 2007 sampling event. During the February 2008 sampling event BEHP was detected in the sample from PL2-258A at a concentration of 1.3 µg/L, which was less than the 2004 groundwater screening level of 3.0 µg/L. Following two additional rounds of SVOC sampling and analysis, USEPA agreed that BEHP was not of concern at the site, and no additional monitoring was required (refer to Attachment S2B). BEHP was included as a constituent of interest in the 2011 Tech Memo, wherein it was identified as a groundwater COPC with the caveat that BEHP is a common laboratory contaminant.

Fewer than 100 BEHP results are available at Plant 2 in groundwater, compared to 900 or more results for most metals and VOCs. As such, the seven results collected during three events in 2008 that exceed the TMCL/FMCL justify retaining BEHP as a COPC, recognizing the possibility that the elevated detections were an artifact of laboratory blank contamination.

To confirm the 2008 detections were anomalous, Boeing will sample and analyze for BEHP under a short-term groundwater monitoring program during semi-annual monitoring events at shoreline wells where BEHP was previously detected (i.e., PL2-258A, PL2-619A, PL2-620A, and PL2-621A). Additional factors justifying this approach and BEHP's status as a pending groundwater COC are described in Attachment S2B, Analytical Considerations for Groundwater Compliance.

2.2.4 Summation Rules

Several analytes are regulated as mixtures that have complex summation rules. The following summation rules were used.

1. Carcinogenic polycyclic aromatic hydrocarbons (cPAHs) were expressed as Benzo(a)pyrene toxic equivalency quotient (TEQ) using summation of toxicity equivalency factors (TEFs) used by Ecology and published in MTCA 173-340-708(e) for each of the seven PAHs that are considered carcinogenic. This summation method was approved by USEPA for use at Plant 2, as documented in the TMCL Tech Memo (Boeing 2011).
2. PCBs are based on the simple addition of the detected Aroclors. Non-detect results were not added to the total of detected results. If all results were non-detect, the highest detection limit was used as the non-detect concentration. In some cases, individual Aroclor results from duplicate analyses were mixed to calculate the total PCB result, when

[4] The Proposed FMCL is the practical quantitation limit (PQL) for BEHP of 1 µg/L, which is greater than the revised TMCL of 0.37 µg/L. The revised TMCL is based on the Washington Clean Water Act-Effective criterion, and is lower than the original TMCL in the TMCL Tech Memo (1.2 µg/L). Data are not available with numeric results between the TMCL and the FMCL; thus, analysis is based on compliance with the FMCL.

one Aroclor result was preferable to another (e.g., if a sample was analyzed twice to properly calibrate the machine in order to quantify the concentration of an Aroclor present in high concentrations within a particular sample). No PCB congener data were collected.

3. Total xylenes are based on the simple addition of the isomers with half of the detection limit used for isomers that were not detected.

Because each of the xylene isomers, PCB Aroclors, and PAHs have slight differences in chemical properties and toxicity factors that impact their calculated risk-based cleanup levels, Boeing and USEPA evaluated whether using TMCLs and FMCLs for the summed analytes, rather than TMCLs and FMCLs developed for individual analytes, would still be protective of human and ecological receptors at the site. It was determined that use of soil and groundwater TMCLs and FMCLs developed for the summed analytes are protective of human health and the environment, for the following reasons:

- For total xylenes, the data are based on different methods over time resulting in different approaches to quantitation and different abilities to resolve isomers, this variability, while low, is on the same order as the variability in the toxicity, which is also low. Treating them as a group avoids confusion and introduces no new variability.
- For PCB Aroclors, three Aroclors (1248, 1254, and 1260) represented more than 95% of the PCB contamination at Plant 2. These three Aroclors are complex mixtures of many of the same congeners. They often present together, and are very difficult to resolve into distinct Aroclors. The FMCL is based on practical quantitation limits (PQLs) in groundwater and soil in the unpaved shoreline area and on a regulatory standard based on total PCBs in the paved industrial area. Tracking them as individual Aroclors would add not impact the numeric value of the FMCL in either soil or groundwater, nor would it change any cleanup decisions.
- For cPAHs, the critical difference was calculation of the soil to protect groundwater to protect surface water pathway. Calculations were evaluated comparing the outcome of the cPAHs as individual species with toxicity based on TEQs, individual partitioning coefficients, and the average distribution of cPAHs in soil samples at Plant 2. Treating the cPAHs as a single entity with the partitioning coefficient for benzo[a]pyrene, resulted in a calculated FMCL for the unpaved shoreline area that was about ½ of the FMCL calculated based on the individual results (57 µg/kg vs. 91 µg/kg). The FMCL for this area was then increased to 140 µg/kg based on background. Again, treating these analytes as a group rather than as seven individual COCs is protective. Calculations are shown in Attachment S2A.

2.3 Summary of Data Quality

Thousands of soil and groundwater samples have been collected at Plant 2 under established sampling, analysis, and quality assurance plans and have been found acceptable for use to make decisions regarding corrective measures, compliance with the Order, and risk management.

The following significant data quality issues were identified: a positive bias/false positive problem with specific metals (arsenic, cadmium, copper, nickel, selenium, and zinc) in saline groundwater samples; and the use of a cyanide method that does not match the method used to develop the regulatory standard used as the FMCL. Table 2-1 identifies specific actions to be taken in the future to resolve these issues. However, sufficient data exist to proceed with CMS remedial alternative decisions.

2.4 Groundwater Cleanup Levels and COCs

This section presents the groundwater media cleanup levels and COCs.

2.4.1 Groundwater TMCLs

Cleanup levels for groundwater are dependent upon the existing and potential future uses of that groundwater. The National Contingency Plan states "USEPA expects to return usable ground waters to their beneficial uses" (40 CFR §300.430[a][1][iii][F]). Generally, the beneficial use of groundwater is either for drinking (i.e., when potable) or for discharge to nearby surface waters. Potability is determined empirically using criteria in Washington Administrative Code (WAC) 173-340-720(2). Based on these criteria, groundwater at Plant 2 is non--potable; the analysis supporting this determination is presented in Volume I of the CMS Report. Surface water is not a contaminated medium at Plant 2. However, groundwater TMCLs must be protective of surface water concentrations that are protective of human health and aquatic species. Therefore, in developing TMCLs for groundwater, the following exposure pathways were considered:

- **Protection of Aquatic Species**. Surface water concentrations that are protective of aquatic species found in three promulgated regulations:
  - Ambient Water Quality Criteria (AWQC) established under Sections 303-304 of the Clean Water Act (33 U.S.C. 1313-14).
  - National Toxics Rule (NTR) criteria established in 40 CFR 131.36.
  - Washington State Surface Water Quality Standards established in WAC 173-201A, which includes standards for chronic and acute exposure to marine and freshwater.
- **Protection of Human Health**. Surface water concentrations that are protective of human consumption of fish and shellfish found in three promulgated regulations:
  - AWQC established under Sections 303-304 of the Clean Water Act (33 U.S.C. 1313-14).
  - NTR criteria established in 40 CFR 131.45.
  - Washington State Surface Water Quality Standards surface water cleanup levels established in WAC 173-201A-240.

These regulations contain provisions for developing modifications to the standard calculations that are protective of sensitive populations. USEPA determined that sensitive populations are present in the Lower Duwamish Waterway area, and established modifications to standard calculations that protect tribal populations. For example, the Tulalip Tribes' consumption rate is appropriate because the Lower Duwamish Waterway is naturally brackish and is unlikely (even under "clean" conditions) to have sufficient intertidal shellfish habitat to sustain the higher rate of shellfish consumption that the Suquamish Tribe enjoys on the Kitsap Peninsula. Additionally, cPAHs, methylene chloride, TCE, and vinyl chloride (VC) are considered mutagenic by USEPA; therefore, childhood exposure scenarios include an early-life correction. Other site-specific and sensitive population assumptions included in calculations for various exposure pathways are described in more detail in the 2011 TMCL Tech Memo (Boeing 2011), and in Attachment S2A.

Calculations for the groundwater-to-protect-surface water pathway assume that published bioconcentration factors (BCFs) are available for all constituents of interest and are representative of uptake into fish and shellfish that could occur in the Lower Duwamish. BCFs are available for constituents known to bioaccumulate, but these BCFs vary by orders of magnitude from species

to species and from study to study. For the remaining constituents of interest, BCFs were calculated from partitioning coefficients (some of which were also calculated, rather than measured). For these constituents, the use of BCFs to determine environmental fate introduces large uncertainties into risk calculations.

For constituents with insufficient aquatic species toxicity and partitioning data, groundwater-to-protect-surface water criteria could not be calculated. In these cases, drinking water exposure was considered as a surrogate standard. The use of a drinking water exposure as a surrogate standard does not affect the potability designation or the highest beneficial use for groundwater at Plant 2. The groundwater TMCLs for GRPH are examples of this scenario. The only available surface water standard was "visible sheen," which was considered inadequate for determining compliance at Plant 2; therefore, the MTCA Method A values for GRPH, which are based on consumption of groundwater as drinking water, were used as a surrogate standard.

Finally, as noted in Section 2.1, several TMCLs have been revised since publication and approval of the original 2011 TMCL Tech Memo. Original and revised groundwater TMCLs are presented in Table 2-2 for groundwater COPCs identified in the TMCL Tech Memo (Boeing 2011) Groundwater TMCLs were revised to:

- Account for the presence of certain metals at naturally-occurring concentrations greater than the TMCL, which eliminated iron and manganese as COPCs[5]. Copper and arsenic background concentrations have not changed.
- Correct errors in the TMCL Tech Memo, including a typographical error for TPH and an error in calculations for certain metals in freshwater, wherein the default water hardness value was erroneously used in calculations, rather than the site-specific hardness value approved for use by USEPA.
- Utilize a more scientifically valid BCF for barium.
- Reflect current Integrated Risk Information System (IRIS) toxicity data and current toxicity data and chemical-specific properties and partitioning factors utilized in USEPA Regional Screening Levels (RSL) equations.
- Include June 2015 revisions to the federal AWQCs for the protection of human health.
- Include November 2016 Washington Clean Water Act-Effective Criteria for the protection of human health.

These revisions are described in more detail in Attachment S2A, and sometimes result in removing a constituent from further consideration as a COC at Plant 2. Constituents affected by these revisions are noted in Table 2-2.

[5] Natural background conditions for iron and manganese are described in Section 1.4.4.6 and in Volume I. Natural background conditions for arsenic and copper were determined in 2006, and have not changed; the technical memorandum establishing the development and use of background values for arsenic and copper is provided in Attachment S2C.

2.4.2 FMCLs

FMCLs are proposed as part of the CMS. They are shown in Table 2-2. The proposed groundwater FMCLs are equal to the corresponding revised TMCLs, except for the following constituents:

- The TMCLs for PCBs, cPAHs, BEHP, VC, and 1,2,4-trichlorobenzene are less than the available PQLs. The FMCLs are based on the use of the PQLs. The specific PQLs selected are generally from Ecology's 2015 Water Quality Permit Writer's Manual, which defines the PQL that must be met for compliance with standards derived under WAC 173-201A and 40 CFR 141.45 (the underlying source for these standards). More information on FMCLs for each of these five constituents is provided in Attachment S2D.
- For TPH, the TMCL was based on Ecology's MTCA Method A values to protect drinking water. The only available surface water standard was "no visible sheen," which was not considered a sufficiently conservative standard. Fortunately, many of the most mobile constituents in petroleum products (benzene, toluene, ethylbenzene, total xylenes [BTEX] and naphthalene) have established surface water standards. Rather than establishing a TPH FMCL for surface water, the existing FMCLs for the more mobile constituents of petroleum products are proposed for use as a surrogate. Effectively, this assumes that by bringing the most mobile constituents into compliance with their FMCL, TPH concentrations will be protective of human health and the environment. The TMCLs and FMCLs for BTEX and naphthalene are presented below.

TPH Constituents	TMCL µg/L	FMCL µg/L
Benzene	2.0	2.0
Ethylbenzene	1.7	1.7
Toluene	520	520
Total Xylenes	1,500	1,500
Naphthalene	26	26

Groundwater TMCL calculations intentionally overestimate risk by ignoring such natural processes as biological degradation and soil attenuation, and by including theoretically-based BCF factors that have not always been confirmed with high quality experimental bioaccumulation data.

For some COPCs (e.g., TPH and TCE) that are expected to be driving factors for corrective measures performed in many of Plant 2's RAs, reliance on a conservative TMCL may represent an overstatement of risk that would dramatically increase the cost and/or complexity of implementing corrective measures at Plant 2, while failing to offer any additional protection to human health or aquatic species. In these instances, Boeing may propose to EPA, for EPA's review and approval, one of the following:

- Use of an FMCL during the Corrective Measures Implementation (CMI) that utilizes existing soil and groundwater data to account for site-specific attenuation or conditions.
- Use of existing and potential future data to derive a site-specific attenuation factor between the shoreline monitoring well network and the discharge point.

2.4.3 Groundwater COPCs and COCs

Figure 2-1 outlines the process used to establish the groundwater COCs and associated "exceedance areas." The term "exceedance area" was proposed by USEPA for this site because many of the groundwater areas that will be discussed represent isolated FMCL exceedances rather than groundwater plumes. Groundwater plumes, especially of TCE and its degradation products, do exist at Plant 2; but not all exceedance areas constitute plumes. For consistency, all areas of groundwater with concentrations greater than their FMCLs are referred to as groundwater exceedance areas.

Groundwater COPCs were developed originally in the 2011 TMCL Tech Memo (Boeing 2011) and are constituents that exceed the TMCL in groundwater collected from Plant 2 wells and from direct push probes. The COPCs developed in the TMCL Tech Memo were intentionally selected to be inclusive of constituents that would likely be eliminated in later data analysis steps.

The first step in Figure 2-1 begins the groundwater COC identification process. The groundwater data set includes all groundwater data from all monitoring wells (both shoreline and interior wells at Plant 2) collected since 2005, except where an active groundwater IM has been implemented. In areas where an IM is being performed, the most current groundwater data from the IM has been used, rather than the pre-IM data, except when an IM is ongoing. In both cases, the end date for the groundwater dataset used to identify COCs was August 28, 2013.[6] The groundwater direct push probe data were not included in this step. The groundwater direct push probe data were collected during earlier investigations to help define the extent of groundwater contamination and were critical for this purpose. However, they are not as accurate or precise as well data, and were not intended for use in determining compliance. The direct push probe data were not used to define groundwater COPCs; the absence of push probe data does not cause any constituents to be eliminated as groundwater COPCs that would otherwise be retained.

The result of this step is that COPCs that were rarely detected (detected in less than 1 percent of locations) and that were only detected at low levels (less than 2 times the FMCLs) did not become COCs. This step also eliminated COPCs that have been successfully remediated in the last decade, including several metals that were COCs due solely to detections in groundwater samples from the Southwest Bank, an area which was subsequently removed.

Groundwater COCs are defined as constituents detected in groundwater at concentrations that exceed their FMCLs; in the case of FMCLs based on PQLs, any detection is considered an exceedance.

Table 2-3 presents the results of screening groundwater data against the FMCLs. Information summarized in Table 2-3 indicates the following:

- Five metals and free cyanide have been retained as COCs, although cadmium, nickel, and cyanide all have data or analytical issues (see footnotes to Table 2-3 and Section 2.2) and have been retained at select locations pending additional sampling.

[6] This dataset was developed in 2014, and is a conservative representation of groundwater conditions. In some areas of Plant 2, more recent data reflecting newer analytical methods or post-interim action conditions have been collected and analyzed. Recent data is shown on figures and discussed in later sections of the CMS.

- Petroleum constituents (GRPH, DRPH, MoRPH, and benzene, ethylbenzene, and naphthalene), PCBs, and three cVOCs have been retained as organic COCs, as discussed in Table 2-3. BEHP has data or analytical issues; as a result, it has been retained as a pending COC at select locations.
- The COCs with the most locations that exceed the FMCL are TCE, VC, copper, and arsenic.

2.4.4 Point of Compliance and the Shoreline Monitoring Network

The highest beneficial use of groundwater at Plant 2 is protection of surface water; therefore, the POC for groundwater at Plant 2 is the location at which groundwater discharges to surface water in the Lower Duwamish Waterway. Although seep sampling has been performed at Plant 2, it is not as convenient as sampling groundwater monitoring wells installed upgradient of the shoreline. Therefore, the shoreline monitoring well network is proposed for measuring compliance at Plant 2 for groundwater-for-the-protection-of-surface water.

The existing network of shoreline monitoring wells has been sampled routinely since 2001. Part of the existing system had to be decommissioned for shoreline interim and corrective measures. On June 3, 2014, USEPA approved the CMI Phase Monitoring Well Installation Work Plan (EPI 2014), which included a major update to the shoreline monitoring well network in anticipation of long-term monitoring objectives; further modifications may be made as part of the CMS. Additionally, the shoreline monitoring program is ongoing, and future monitoring may result in additional changes.

Finally, this document often compares results in the shoreline monitoring well network and in other wells directly to the FMCLs. This comparison often ignores the POC, and further ignores chemical and biological attenuation between the shoreline monitoring well network and the actual discharge point to the waterway.

2.4.5 Summary of Groundwater COCs and FMCLs

Table 2-4 summarizes the COCs for groundwater, their FMCLs, and whether they have historically reached the shoreline area as demonstrated by exceedances in the shoreline monitoring well network. Groundwater FMCLs are typically numerically equivalent to their TMCLs, except in cases where the TMCL is below quantitation limits that may be reliably achieved by the laboratory. In these cases, the FMCL has been set at the current PQL, as described in Attachment S2D.

The current nature and extent of the COCs is discussed in Section 4.0, after an overview of the numerous interim and corrective measures performed at Plant 2 in Section 3.0.

Section 4.0 continues the process shown in Figure 2-1 by describing the spatial distribution of the COCs across the site and with depth. Section 4.0 also identifies the exceedance areas and identifies those exceedance areas that reach the POC at the waterway.

2.5 Soil Cleanup Levels and COCs

This section presents the soil media cleanup levels and soil COCs.

2.5.1 The Industrial Nature of Plant 2

Since the time of the original Plant 2 Order and throughout the TMCL process, it has been anticipated that Plant 2, located in the heart of the industrial corridor of south Seattle, would remain an industrial facility, and that Boeing would record an environmental covenant which contains restrictions consistent with industrial use. The Order and the TMCL Tech Memo (Boeing 2011) allow for and envision the development of FMCLs based on site-specific conditions and institutional controls:

"Site-specific conditions may include, but are not limited to, consideration of attenuation, degradation, and other related processes. Engineering and institutional controls may include, but are not limited to, pavement to reduce infiltration and block access, monitoring, and restricted access to industrial areas, and restrictive [environmental] covenants."[7]

FMCLs for direct contact have been developed for both the paved industrial area and unpaved shoreline area and differ in value to reflect the different potential exposures in these areas.

The specific language of the environmental covenant will be developed to reflect the SOB because sufficient information would be available at that time to write and approve an appropriate environmental covenant. Attachment S2E is a draft environmental covenant based on Ecology's 2016 template[8]; it is included as an illustrative example of what the environmental covenant for Plant 2 is expected to look like. Environmental covenant elements that are expected to be incorporated into the final environmental covenant are described in the bullets that follow, and act as a basis for later assumptions in this document.

- The site will remain an industrial facility where site exposure is limited to 50 weeks per year, and 50 hours per week work periods (on average) over a 30-year exposure period. It is assumed that part of the workforce may work in offices, and that part of the workforce may include pregnant women. Should a section of the site be set aside for a different purpose, non-residential childcare facilities for example, at some time in the future, Boeing will need to demonstrate that the corrective measure in that portion of the site is protective of that exposure.
- The industrial areas of the site will remain paved and/or covered by buildings that contain slab on grade foundations. The buildings may also contain subsurface utilities and additional piling support. The key to this assumption is that infiltration of rainwater, except in the unpaved shoreline area, or minimal landscape areas required by City ordinance, is limited to conditions similar to current conditions (or less than 10 percent infiltration).

Though it may not be required by the environmental covenant, the industrial areas of the site are expected to remain fenced and have limited access and security requirements.

Although all of Plant 2 is zoned and developed as industrial property, there are two different types of land use at the site. More than 90 percent of the land is within the fenced and controlled sections of Plant 2. This portion of the site is paved or covered with buildings, has controlled and

[7] Section 7.0, Summary, of the TMCL Tech Memo (Boeing 2011).

[8] Ecology's template was used because Plant 2 is expected to transition to Ecology-lead for long-term maintenance and monitoring as is customary for RCRA cleanup sites.

limited access, and is actively used by the Commercial Airplane Division of Boeing. This portion is referred to as the paved industrial area of Plant 2.

The remaining 10 percent is along the shoreline and consists of unpaved, landscaped areas that transition into the North and South Habitat Areas built in 2012-2015. The unpaved shoreline area also contains lined stormwater swales. Access to the unpaved area is difficult as it requires passing through the fenced industrial area, or walking on the shoreline at very low tides and then climbing up a steep vegetated bank through one of the habitat areas. This second type of area is referred to as the unpaved shoreline area. The locations of the unpaved shoreline areas are shown in Figure 2-2.

2.5.2 Residential Versus Industrial Exposures

As part of the TMCL process, residential direct contact exposures were considered and residential screening levels were developed using both USEPA's RSLs and MTCA Method B approaches. Figure 2-2 presents a simplified view of soil data at Plant 2. Circles represent locations where subsurface soil data exist. Four conditions are shown on the map, as follows:

1. A green dot indicates that all soil results in the vadose zone (ground surface to approximately 11 feet bgs) are below their respective residential screening levels (the lower of MTCA Method B[9] or USEPA's RSL).
2. A blue dot indicates that one or more soil results at that location exceed the residential screening levels, but not the FMCL.
3. A red dot indicates that one or more soil results at that location exceed the FMCL, which is based on the industrial screening level (the lower of MTCA Method C[10] or USEPA's industrial RSLs as modified for Plant 2 [see Section 6.0]).
4. A grey dot indicates that detection limits for one or more results exceed either residential screening levels or industrial FMCLs; however, no soil results were detected at levels exceeding either residential screening levels or industrial FMCLs.

From review of Figure 2-2, there are localized, well-defined areas with concentrations greater than the FMCL or single isolated data points. These areas with red dots will be identified in later sections of this report as areas to be evaluated for corrective measures. The blue dots represent scattered, low-level exceedances of residential screening levels; most of these are co-mingled with clean sample locations. Since these concentrations are protective of industrial workers and site usage will be constrained in the future with an environmental covenant, it is neither necessary nor cost-effective to remediate these very scattered low-level concentrations. In areas where low-level exceedances are co-mingled with exceedances of industrial standards, the corrective measures discussed later in this report will also generally remove a significant amount of, if not all, low-level contamination during removal of the soil with concentrations exceeding FMCLs.

In the unpaved shoreline area, there are very few exceedances of the residential standard following extensive soil removals conducted as IMs during 2010-2015 redevelopment and habitat

[9] As is customary for soil samples, MTCA Method A unrestricted land use cleanup levels were used for arsenic, TPH, and lead.

[10] As is customary for soil samples, MTCA Method A industrial levels were used for lead and PCBs, and the state of Alaska's free product levels for silty sand were used for TPH.

construction. Because they are unpaved and have fewer access controls, Boeing is proposing in Section 2.5.4 to use unrestricted land use cleanup levels, rather than industrial cleanup levels, for the soil FMCLs in this area. Although the industrial cleanup levels would be protective of any reasonable potential recreational or trespass exposure scenario, the costs of bringing the unpaved shoreline area into compliance with unrestricted land use cleanup levels is expected to be off-set by decreased permitting or other costs along this section of shoreline.

If at some point there is a modification to the industrial zoning designation for the property together with a corresponding desire to alter the actual site use to be in keeping with this new designation, there would need to be advanced approval from Ecology for such altered use. A zoning change may mean that cleanup of the property and restrictions for industrial property which are captured in an environment covenant are no longer considered to be protective. In that case, the owner may need to conduct further remediation of the site to achieve more stringent cleanup levels, and also modify the environmental covenant to capture any altered use restrictions. These activities would need to be authorized by Ecology.

2.5.3 Soil TMCLs and Point of Compliance

The soil TMCLs at Plant 2 were developed considering the following pathways and receptors:

1. Direct contact to industrial workers, including ingestion, dermal contact, and inhalation of dust. For the purposes of this calculation, the site is assumed to be unpaved and to allow access of vadose-zone soils by industrial workers. Considering that the site is paved and/or covered by structures, this is an extremely conservative assumption.
2. Direct contact to a fulltime resident. This scenario was intended to represent a “clean site” available for unrestricted use; it has been developed for use in this chapter for context only.
3. Protection of groundwater quality (represented by the groundwater TMCLs), using MTCA’s standard leaching calculations and relying on measured groundwater concentrations that reflect actual conditions.
4. Protection of bank sediments from soil erosion. Ecology sediment management standards (WAC 173-204) were used to evaluate whether eroded soil adjacent to a bank could pose a risk to sediment.

The soil TMCL for each constituent was selected based on the lowest of these pathways, after background concentrations were considered.

Certain soil TMCLs have been revised since the 2011 publication and approval of the TMCL Tech Memo (Boeing 2011), consistent with the revisions described in Section 2.1 for groundwater. That is, revisions were made to incorporate newly promulgated water quality standards; correct typographic errors or errors in calculations; to update toxicity factors consistent with newly available toxicity information published in IRIS; and to update calculations for the soil to protect groundwater pathway. These revisions are described in Attachment S2A. Both the approved 2011 soil TMCLs and the revised TMCLs are presented in Table 2-5, along with the justification for any revision that was made to a 2011 TMCL for all constituents retained as soil COPCs after the analysis of site data performed in Appendix B of the TMCL Tech Memo (Boeing 2011).

The soil cPAH TMCL was adjusted for background considerations. The discussion for this adjustment is contained in Attachment S2C. The presence of background levels of cPAHs in urban soil is well known across the country. The City of Seattle, with assistance from Ecology and USEPA, measured cPAHs, PCBs, and dioxin/furans in urban soils near the roadways in residential communities in Seattle (Ecology 2011). Based on these data, Boeing requested changing the soil TMCL for cPAHs from the benzo(a)pyrene TEQ of 15 µg/kg (which was based on an un-calibrated leaching model) to 390 µg/kg (the background concentrations from the City of Seattle study). However, USEPA indicated that the value of 390 µg/kg was not sufficiently studied to be acceptable; USEPA recommended using the residential direct contact cleanup level of 140 µg/kg. This has been adjusted in the revised TMCL column in Table 2-5.

The soil TMCLs are combined with a POC where the TMCL must be met. At Plant 2, the soil POC is the vadose zone, which corresponds to soil between 0 and 11 feet bgs. This POC will also be used to evaluate compliance with FMCLs.

Figure 2-3 outlines the process for identifying the soil COCs and exceedance areas, much like Figure 2-1 did for groundwater. Soil TMCLs include both leaching and direct contact pathways, with the conservative leaching pathway commonly being the basis for the TMCL. The soil data were screened in the 2011 TMCL Tech Memo (Boeing 2011) against the TMCLs to identify COPCs. The COPCs and revised TMCLs are presented in Table 2-5.

Soil data was screened again in this document to identify COCs following the incorporation of TMCL revisions and revision of the soil dataset to reflect very extensive soil cleanups performed between 2010 and July 2013. For VOCs, the soil dataset includes samples collected between January 1, 2005, and July 17, 2013; for all other constituents, the dataset includes all samples collected prior to July 17, 2013. In some areas of Plant 2, soil cleanups that took place between July 2013 and December 2016 have further improved soil quality at Plant 2; therefore, maximum concentrations and exceedance factors shown on figures in Section 4.0 and 6.0 are often lower than the maximum concentrations reported in Section 2.0 tables. All Plant 2 soil data in the RCRA database representative of soil remaining in place through December 31, 2016 was used to evaluate the need for soil corrective measures.

2.5.4 Soil FMCLs and Leaching Screening Levels

The soil TMCL discussed was developed based on consideration of four different exposure pathways, as discussed in Section 2.5.3. It is significantly easier to make cleanup decisions about soil if the exposure pathways are broken into two types of exposure: direct contact (humans) and potential to leach to groundwater. Characteristics of the two primary site areas (the paved industrial area and unpaved shoreline area) are summarized in the table below in conjunction with the different types of exposure that occur in these areas and that contribute to the differences between the FMCLs for the two areas. As indicated in the table below, the leaching SL is protective of groundwater regardless of site area.

Land Use Exposure	Paved Industrial	Unpaved Shoreline
Characteristics		
Paved/Covered	Yes	No
Fenced, controlled access	Yes	No, but access difficult
Environmental Covenant	Yes	Yes, due to habitat areas
Exposures		
Direct Contact	Adult only Industrial worker	Adult only Trespassers & industrial workers
Protection of Groundwater	Groundwater data from wells and probes used to determine compliance and areas needing corrective actions	
Cleanup Levels		
FMCL	Direct contact, industrial worker	Lower of direct contact, unrestricted exposure and sediment FMCL/fill requirements
Potential Leaching (Leaching SL)	Evaluate groundwater results	

Soil FMCLs in both areas are based on direct contact scenarios. FMCLs for soils in the paved industrial area are based on direct contact risk values for industrial exposure. Two industrial scenarios were considered in the development of TMCLs for each constituent: the USEPA RSL adjusted to a cancer risk of 1.0×10^{-5} and an increased ingestion rate of 200 milligrams per day (mg/day) and the standard MTCA Method C scenario. In August 2013, USEPA confirmed that use of another soil ingestion rate of 100 mg/day was appropriate for workers in the paved industrial area at Plant 2 with limited contact with the site's soils (i.e., in areas of the site covered by pavement). Therefore, the FMCL for the paved industrial area is the lower of the USEPA RSL (with a soil ingestion rate of 100 mg/day) and the MTCA Method C industrial risk values. They are presented in the last column of Table 2-5, and are applied to soils in the paved industrial area within the vadose zone of 0 to 11 feet bgs.

The FMCLs for the unpaved shoreline are based on the lower of direct contact for unrestricted land use and SMS SQS to protect the adjacent habitat areas. Two residential scenarios were considered: the USEPA RSL for residential exposures and the standard MTCA Method C exposure for residential or unrestricted land use. The lower value was selected for all COPCs. The proposed shoreline soil FMCLs for the unpaved shoreline area are presented in the next to last column in Table 2-5; they are also applied to the whole vadose zone (0 to 11 feet bgs).

Soil screening levels for leaching (leaching SLs) are also presented in Table 2-5 in the column titled "Modeled Leaching Component of the TMCL." Leaching SLs are applied to the lower vadose zone of 6 to 11 feet bgs in the paved industrial area. In this area, stormwater infiltration is sufficiently restricted to make leaching in the dry vadose zone negligible. The 6 to 11-feet-bgs zone accounts for possible leaching under unusually high groundwater conditions and tidal influences in the unpaved shoreline area.

2.5.5 Soil COCs for Paved Industrial Area

Table 2-6 compares soil concentrations in the paved industrial area to the FMCLs. As a result of the many IMs and redevelopment actions undertaken by Boeing and described in Section 3.0, only four constituents are COCs in soil in this area: free cyanide, cPAHs, PCBs, and TPH. TPH cleanup levels are based on prevention of free-product formation and, therefore, vary by product type; gasoline and mineral spirits have an FMCL of 7,500 milligrams per kilograms (mg/kg), while diesel and heavier products have an FMCL of 17,000 mg/kg. Because of the large number of IMs and demolition and redevelopment projects over the last 20 years in the paved industrial area, less than 1 percent of the samples have exceedances of TPH, free cyanide, and/or PCBs; less than 2 percent of the samples exceed for cPAHs. The primary area of concern is cPAHs in the OA 18 area. This and any other area with soil FMCL exceedances will be discussed further in Sections 4.0 and 6.0 of this report with respect to their footprint and potential corrective measures. The red dots in Figure 2-2 give an overview of current soil conditions, and identifies soil locations with one or more results that exceed the FMCLs. Current conditions are described in Section 4.0, which also presents detailed figures showing the location and depth of soil COCs that exceed their respective FMCLs.

2.5.6 Soil COCs for Unpaved Shoreline Area

Table 2-7 compares soil concentrations in the unpaved shoreline area to the FMCLs. The only COC that remains for this area is TPH in the gasoline and heavy oil fractions. This COC exceeds the residential-based FMCL that was developed by Ecology to protect a drinking water pathway that does not exist in this area (both the groundwater and the adjacent waterway are brackish to saline). Detailed analysis of the TPH in this area, including leaching studies, indicates that transport through this material is limited, such that the concentrations detected in the unpaved shoreline area in soil are protective of groundwater.

Because of the large number of IMs and demolition and redevelopment projects over the last 20 years, very little contamination remains in the unpaved shoreline area. For example, less than 7 percent of samples have exceedances of GRPH; less than 4 percent of the samples exceed for TCE. The limited number of soil sample results with FMCL exceedances will be discussed further in Section 6.0, with respect to their footprint and potential corrective measures. The blue dots in Figure 2-2 give an overview of the locations with one or more results that exceed the proposed unpaved shoreline soil FMCLs. Current conditions are described in Section 4.0, which also presents detailed figures showing the location and depth of soil COCs that exceed their respective FMCLs. Additionally, residual oil contamination remains in the unpaved shoreline area at depths greater than 11 feet bgs; this contamination is discussed in Attachment S2F.

2.5.7 Soil Concentrations and the Leaching Pathway

Soil concentrations must also be protective of groundwater quality. Because of the institutional controls, such as pavement and stormwater controls that are in place at Plant 2, the groundwater data from the paved industrial area are directly applicable to assessing this pathway. The fourth box in Figure 2-3 outlines this evaluation. Soil data from 6 feet bgs and deeper are compared to the SLs for leaching in Table 2-5. If the soil concentrations are below the SLs, then the conservative leaching model demonstrates that the concentrations are protective of groundwater quality.

If the soil concentrations exceed the SLs, then the groundwater data are evaluated. If the groundwater data indicate compliance with the groundwater FMCLs, this demonstrates that soil

is protective of groundwater, and the constituent is not a COC for soil in this area. Some soil constituents that exceed the leaching SLs are not groundwater COCs at Plant 2 and can be eliminated at this stage throughout the site. This elimination is summarized in Table 2-8 for the paved industrial area and in Table 2-9 for the unpaved shoreline area. If the groundwater data indicate that leaching is occurring, then the area is identified as a combined groundwater and soil exceedance area for further evaluation.

The complex evaluation of the leaching pathway using combined groundwater and soil data does not lend itself to a simple summary map. Section 4.0 contains more detailed maps and discussion specifically focused on the soil-to-groundwater pathways for those constituents where groundwater data indicate that leaching may be occurring.

Table 2-10 summarizes the COCs for soil and groundwater, with additional details in the text and figures in Section 4.0.

3.0 INTERIM MEASURES AND SITE CHANGES

This section summarizes actions and activities that have impacted soil and groundwater quality at Plant 2 since completion of the RFI in 1998 and in accordance with requirements of the Order. Site soil and groundwater quality has improved because of the performance of IMs, soil excavations/removal actions required to support construction projects, facility upgrades, demolition and/or construction of infrastructure, and the demolition or construction of the site's buildings. These activities were conducted under the acknowledgment or approval of USEPA and documented in work plans, technical memorandums, and completion reports submitted to USEPA. Minor or emergency excavation activities were communicated via email to the USEPA project manager.

3.1 Soil Removal Actions – Construction Projects, Interim Measures, and Redevelopment

Between approximately 1995 and December 2016, more than 98 soil excavations/removal actions have been conducted on site. The size of excavations and associated volumes of soil range from a few cubic yards (cy) for the installation of a utility pole to greater than 10,000 cy associated with construction of the south Plant 2 stormwater system upgrade during the 2011–2012 redevelopment project totaling over 60,000 cy. Table 3-1 and Figure 3-1 identify historical excavations and soil removal actions. Attachment S3A (on USB) contains the documents and communication that summarize historical excavations and soil removal actions associated with IMs and construction projects presented in Table 3-1.

The 2010-2012 Demolition/Redevelopment was by far the largest of these activities; it incorporated numerous soil removal actions that involved large volumes of contaminated soil, which greatly improved Plant 2 soil quality. From 2010 through 2012, demolition and redevelopment activities were conducted over a 35-acre area and included demolition of Buildings 2-40, 2-41, 2-44, 2-49, the 2-60s/2-66 slabs, and the west portion of Building 2-31 (Figure 3-1). Demolition of buildings and pavements included removal of building superstructures; concrete floor slabs; and subgrade sumps, pits, vaults, and associated infrastructure.

The building floor slabs and subgrade infrastructure were generally removed to within approximately 100 feet of the Duwamish Waterway. The slabs located within 100 feet of the waterway were left intact for subsequent demolition in 2013 as part of the DSOA and Southwest Bank Corrective Measure work.

Redevelopment work conducted from 2010 through 2012 included the following:

- Removal of approximately 60,000 cy of concrete slabs, foundations, and underground structures.
- Removal and disposal of approximately 1,200 cy of PCB-contaminated concrete managed as Toxic Substances Control Act (TSCA) waste.
- Removal and disposal of approximately 60,000 cy of impacted soil.
- Processing, analysis, and placement of approximately 113,500 tons (56,000 cy) of recycled crushed concrete used as backfill for the redevelopment project (recycled from Plant 2 slabs).
- Import and placement of approximately 125,000 tons of clean soil backfill.

- Placement of approximately 30 acres of asphalt pavement over the soil surface following soil cleanups in the area of the demolished buildings in the 2-40s Area.
- Demolition of the tunnels under Buildings 2-40, 2-41, and 2-49, and placement of clean fill material and recycled crushed concrete backfill in the tunnel excavations.
- Construction of a new stormwater system, including 14,000 linear feet of new stormwater lines, five lined bioswales, three stormwater treatment vaults, and three outfalls in the 2-40s, 2-60s, 2-66, and 2-31 areas.
- Installation and then decommissioning 173 monitoring wells following their use.

Figure 3-2 reflects current site conditions following IMs and construction projects, facility upgrades, and demolition and/or construction of infrastructure and buildings.

3.2 Soil and Crushed Concrete Backfill

During the demolition and redevelopment activities from 2010 to 2012, soil, stormwater, and concrete were managed in accordance with USEPA-approved IM work plans, and completion reports that document site activities including field monitoring, soil sampling, and waste disposition, are referenced in Section 8.3. Attachment S3B presents analytical data on crushed concrete backfill and soil backfill and location information.

Demolition of the buildings, concrete slabs, and pavement areas removed what was essentially a “cap” over the vadose soils and groundwater. Vadose soils and/or groundwater were historically impacted with chemical constituents above the applicable criteria in a number of locations within the demolition footprint. Impacted soils were removed in specific target excavations during the 2010-2012 demolition and redevelopment activities (Figure 3-1 and Table 3-1). Data corresponding to excavated soil were removed from the Plant 2 active database and replaced with post-construction or post-IM sampling results to represent current site conditions.

Except for the area within 100 feet of the Duwamish Waterway and small landscaped areas, the remainder of the demolition and redevelopment area was covered by asphalt paving. The area within 100 feet of the waterway was addressed as part of DSOA and Southwest Bank Corrective Measure activities conducted from 2012 through 2015.

3.2.1 Soil Backfill

From 2010 to 2012, soil excavated during demolition and redevelopment activities was managed in accordance with the USEPA-approved work plans (Golder 2010b, 2011a, 2011b). Excavated soil was appropriately managed and characterized as necessary to determine final disposition as reuse on or off site. Soils were stockpiled on site and managed for reuse on site or loaded into trucks for transport off site for use as daily landfill cover, disposal as hazardous waste, or treatment and disposal as hazardous waste.

Excavated soil was used as backfill only if it did not exceed proposed industrial soil FMCLs and if it was placed as backfill in areas that will remain in industrial use and at an elevation approximately 1.5 feet above the historical high level of groundwater (Figure 3-3). Attachment S3B identifies sample locations that represent the soil used as backfill. Approximately 125,000 tons of clean soil was imported for backfill in support of the 2010-2012 Plant 2 demolition and redevelopment project. Analytical data representative of the import soil is provided in Attachment S3B.

3.2.2 Crushed Concrete Backfill

Prior to initiation of the 2010-2012 site demolition and redevelopment, concrete pavement, building slabs, and below grade concrete structures (pits and sumps) were characterized with respect to PCBs. More than 270 concrete structures and small areas of concrete slabs were identified with PCB concentrations that exceeded the 50 mg/kg TSCA limit. Removal, confirmational sampling, and disposal of TSCA-regulated concrete from the demolition of Buildings 2-40, 2-41, 2-44, 2-49, and the western portion of 2-31 was conducted in accordance with the USEPA-approved work plan (Landau 2011). Concrete associated with these TSCA removals was not crushed but was disposed of off site at a permitted Subtitle C landfill.

A TSCA Risk Based Determination Approval (RBDA) was established for the 2010-2012 redevelopment project, which allowed for the use of crushed demolition concrete less than 50 mg/kg PCBs to be used as site fill. Boeing chose to implement the RBDA using a criteria of less than 10 mg/kg. Applicable RBDA requirements were coordinated with the USEPA TSCA office and any crushed concrete used as fill was handled consistent with the TSCA RBDA requirements.

The remaining concrete with PCB concentrations below 10 mg/kg was crushed to an approximate size of 1¼-inch minus. The crushed concrete was sampled and analyzed for PCBs in accordance with the RBDA to document the PCB concentrations in the crushed concrete re-used as backfill (Figure 3-4). The crushed concrete (with PCBs less than 10 mg/kg) was re-used as backfill on site in the paved industrial area only. Crushed concrete was not placed below 1.5 feet above the historical high groundwater level. Crushed concrete with concentrations greater than 10 mg/kg was landfilled off site at a permitted Subtitle D landfill. The mean concentration of PCBs in the crushed concrete used as backfill was 1.1 mg/kg. Attachment S3B presents analytical results for crushed concrete used as backfill. The *Work Plan Completion Report, TSCA Material Management, Plant 2 Demolition Area* (Golder 2013b), provides additional details, analytical data, drawings, and records that document the concrete management.

A copy of this document will be submitted to the TSCA group at USEPA as final fulfillment of the RBDA. The presence and location of the crushed concrete fill will also be included in the environmental covenant for the site.

3.3 DSOA and Southwest Bank Corrective Measure

The DSOA and Southwest Bank Corrective Measure was completed in 2015. The approval from USEPA was documented in a letter titled: *Final Decision and Response to Comments for Boeing Plant 2 Sediments, Duwamish Sediment Other Area and Southwest Bank, Boeing Plant 2, Seattle/Tukwila, Washington, Resource Conservation and Recovery Act (RCRA) Docket No. 1092-01-22-3008(h) EPA ID No. WAD 00925 6819 (USEPA 2011b)*. The work also included the construction of the large habitat areas. Section 8.0, References includes a list of the key decision, design, and construction completion documents for the work. The work also was performed under a USACE Section 10/404 Permit and under a series of RBDAs from the TSCA Unit at USEPA. The submittal of the final version of this report to the TSCA Unit completes the reporting requirements under the RBDA.

In areas where this work extended into the uplands at Plant 2, over 46,000 cy of soil were removed to meet the goals of the DSOA and Southwest Bank Corrective Measure and the unpaved shoreline FMCLs. In the riparian fringe, any contamination above the unpaved shoreline area

FMCLs has been discussed in this report. An example of this is the unpaved shoreline area beneath the 2-10 building where access to the sediment was not possible.

3.4 OA 11 Interim Measure

In 2001, Boeing discovered a release of PCBs adjacent to the Seattle City Light (SCL) West Bank Substation within Plant 2. This area is contained within an area previously designated under the RCRA Order as OA 11. OA 11 originally included both former Building 2-72 (a small shed used for general storage) and the former fenced West Bank Substation due to the presence of PCBs and TPH previously found in soil and groundwater. Building 2-72 and the transformers, formerly located on the concrete pad of the West Bank Substation, were removed in 2004.

In early 2016, the RCRA program and Boeing determined that the corrective measure for OA 11 should be performed as an IM jointly with the TSCA program under a RBDA. Performing this IM allowed Boeing to complete property improvements necessary for stormwater compliance in that area of Plant 2.

The IM consisted of excavation of soil primarily impacted with PCBs and TPH; low levels of cVOCs (i.e., TCE and VC) were also concurrently removed. The excavation was completed between September 6 and 20, 2016. A total of approximately 50 cy of Subtitle C soil and pipe debris totaling 124 tons, and approximately 650 cy of Subtitle D soil totaling 1,020 tons were excavated as part of the IM. In addition, approximately 78 tons of debris (including the former transformer pad, inactive stormwater features, and other miscellaneous debris) were removed and transported to a Subtitle D landfill for disposal.

After excavation, gravel borrow from an approved source was used to backfill the excavation and restore the grade of the ground surface to drain toward adjacent stormwater catch basins. Final grading, placing a 3-inch thick layer of compacted base course, and paving were completed in October 2016. The construction completion report detailing the OA 11 IM is included in Attachment S3A.

Boeing has completed the approved scope of RCRA requirements in OA 11 with the completion of the IM in 2016; additional investigation data suggests a source other than Boeing for the PCB contamination discovered immediately south of OA 11 on the Jorgensen Forge property.

3.5 Groundwater Interim Measures

Areas of impacted groundwater in Plant 2 have undergone a variety of IMs, generally designed to contain or reduce contaminant mass within the impacted area. IMs are not specifically designed to achieve regulatory cleanup levels such as the TMCLs or FMCLs for Plant 2; however, some of the technologies used to perform the groundwater IMs are capable of effectively achieving TMCLs and FMCLs.

Table 3-2 presents the groundwater IMs that have been performed or are currently being performed at Plant 2 and lists the associated documents. Detailed descriptions of the groundwater IMs and associated documents are included in Attachment S3C and referenced in Section 8.4. General locations of these IMs are shown in Figure 3-5.

3.6 Adjacent Cleanup Actions at Jorgensen Forge

Directly south of Plant 2 is the Jorgensen Forge facility; active operations at the plant include aluminum and custom steel forging and machining. There are three active cleanup orders on the site as follows:

- A Joint Boeing and Jorgensen Forge USEPA Administrative Order on Consent under the CERCLA for the cleanup of the property line outfalls (two historical stormwater outfalls and associated pipes that run parallel to the property line on the Jorgensen side). This site is referred to as the Jorgensen Forge Outfall Site (JFOS). Under the original Order (USEPA 2010), the pipes were inspected, cleaned, and decommissioned in 2011. There are Three Modifications to this Order as follows:
    - The First Modification (USEPA 2012) included supplemental subsurface investigations to further define the extent of subsurface PCBs in the vicinity of the outfalls and west of the pipe transition from clay to corrugated metal pipe (CMP). The supplemental subsurface investigations were completed in 2011 and 2012 and indicated the presence of elevated PCB concentrations beneath the east bank of the Duwamish Waterway.
    - The Second Modification (USEPA 2013) included an investigation of the soil beneath the east bank of the Lower Duwamish Waterway in 2013, and required design and installation of a shoreline bank cofferdam to facilitate the completion of the Jorgensen Forge Early Action Area bank removal project. The cofferdam was installed in 2014.
    - The Third Modification (USEPA 2015) included two stages for the removal of overburden soil, the CMPs, and PCB-contaminated soil; this work extended across the Jorgensen property line onto the southwest portion of the Plant 2 property. Stage 1 was completed in 2015 and included an un-shored excavation to remove a portion of the pipes and associated PCB-contaminated soil. Stage 2 was completed in 2016 and included the installation of a sheetpile enclosure to allow deep excavation of the remaining portions of the pipes and associated PCB-contaminated soil to depths to 32 feet bgs.
- A USEPA Administrative Settlement Agreement and Order on Consent for an Early Action under CERCLA (USEPA 2012) with Earle M. Jorgensen (EMJ) for cleanup of the Duwamish Waterway bank and sediments associated with the facility. The Jorgensen Forge Early Action DMU 5 bank removal project was completed by EMJ in 2014.
- An Ecology-Agreed Order with EMJ (Ecology 2017) under MTCA, for remedial investigation and cleanup of the uplands. COCs include petroleum hydrocarbons, such as a free product plume of cutting oil within 50 feet of the south Plant 2 and Jorgensen Forge property line, cVOCs, metals, and PCBs. Remedial investigation under this Agreed Order has not yet begun.

3.7 Electronics Manufacturing Facility Plume

The EMF plume originates from a former Boeing facility that operated on the east side of the KCIA. Past activities at the EMF site resulted in a release of TCE to the ground, which contaminated groundwater. The EMF cVOC plume was transported downgradient by natural groundwater flow from the former EMF site in a westerly direction across KCIA and into Plant 2. Within Plant 2, the EMF plume is found 30 to 60 feet bgs.

The EMF plume is being remediated using Enhanced Reductive Dechlorination (ERD) under a separate CERCLA Order administered by USEPA. The most recent and most successful remedial technology to degrade cVOCs within the EMF plume is ERD. Boeing is conducting ongoing nutrient substrate injections under the CERCLA Order to promote and maintain geochemical conditions that are favorable for ERD, and groundwater monitoring to track remedial progress in the EMF plume. Groundwater monitoring data for the EMF plume demonstrate that ERD has successfully decreased the size, concentration, and downgradient extent of the EMF plume. TCE and its degradation compounds: cDCE, and VC have been effectively reduced to levels comparable to the Plant 2 FMCLs throughout the plume in the Plant 2 area.

Boeing will continue to implement the ERD remedial technology and monitor groundwater quality throughout the EMF plume through the EMF CERCLA Order, and ensure coordination between the RCRA Order and the EMF CERCLA Order, to achieve FMCLs over time.

4.0 CURRENT SITE CONDITIONS

Attachment A of the Order titled "Scope of Work for the Corrective Measure Study," requires that this document provide "an update of the current situation at the Facility and the known nature and extent of contamination as documented by the RFI." The soil removal actions, as well as groundwater and soil IMs identified in Section 3.0, substantially changed site conditions from those documented in the RFI. Groundwater monitoring associated with IMs and shoreline network monitoring events provided new information about the nature and extent of contamination and current groundwater conditions. This section describes the updated understanding of current conditions.

4.1 Soil and Groundwater Conditions

From 2005 through 2010, Boeing performed a series of soil and groundwater DGIs in the seven study areas of Plant 2 to fill data gaps that were identified by USEPA and Boeing.

The DGI soil and groundwater data for Plant 2 were presented in seven separate volumes of the CMS identified in Section 1.1 and provided in Attachment S1A.

To support the discussion of the site's current conditions in this report, analytical data collected within the vadose zone (obtained from the Plant 2 RCRA database and representative of soil remaining in place on site) were compared to their respective FMCLs (Figure 4-1). As indicated in Section 2.0, FMCLs for soil are based on industrial and residential exposure scenarios in the paved industrial area and unpaved shoreline area, respectively. Soil in the 6 to 11 feet bgs interval was also evaluated against the leaching SLs. Sample locations were color-coded and are presented in this section's figures to demonstrate where soil COCs were analyzed, whether they were detected, and, if detected, whether they exceed FMCLs or the leaching SLs. Several chemical constituents have similar physical characteristics and have been evaluated and presented as a group in the figures. The constituent groups are identified and further discussed in Section 4.2. A set of soil data for Plant 2 COPCs representing the period after the DGI were completed (August 30, 2010) through the "current" date for CMS purposes (December 31, 2016) is presented in data tables in Attachment S4A.

For groundwater, the interpolated extent of the areas where groundwater samples exceed the FMCLs (i.e., impacted groundwater) is shown for all three levels of the aquifer. Impacted groundwater in the A-Level of the aquifer is presented in figures alongside soil samples collected in the 6 to 11 feet-bgs soil interval. The full set of groundwater COC maps for the seven DGI study areas is presented in Attachment S4B.

Maps for groundwater COCs that were the focus of IM remediation efforts in the 2-10, 2-40s, 2-60s, and 2-66 study areas contain DGI data and, where applicable, more recent groundwater data from the IM. The IM data used in some of the COC maps were collected during the most recent (through December 2016) or the final round of groundwater sampling for the following IM projects:

- 2-10 North and South sheetpiles
- EMF Plume
- OA 9

- OA 1
- 2-66 Sheetpile

In addition, recent shoreline monitoring well data were substituted for DGI data in cases where the recent shoreline monitoring data indicate notable changes in post-DGI groundwater conditions. These IM and shoreline monitoring data are from samples collected through December 2016, and were included to provide more recent concentrations and estimated extents of groundwater COCs at concentrations greater than FMCLs.

For areas where recent data (i.e., post-IM or post-DGI data) are used to represent current groundwater conditions, Boeing has prepared two figures: one shows conditions using pre-IM data; and one figure reflects post-IM conditions. The DGI data sets are more comprehensive geographically than IM and shoreline monitoring data sets; therefore, post-IM figures retain DGI data at most sample locations. Sampling dates associated with the more recent data are presented on the COC maps included in Attachment S4B so DGI and post-IM data can be distinguished. The specific groundwater COCs that are presented on separate maps for DGI and post-DGI data in Attachment S4B are listed for their DGI study area below.

- 2-66 Area: arsenic, benzene, cadmium, cDCE, copper, MoRPH, nickel, TCE, PCBs, VC, and zinc
- 2-60s Area: TCE, VC, and zinc
- 2-40s Area: arsenic, cadmium, copper, nickel, TCE, PCBs, VC, and zinc
- 2-31 Area: arsenic, copper, nickel, TCE, PCBs, VC, and zinc
- 2-10 Area: cDCE, TCE, and V
- North Area: cadmium, copper, nickel, PCBs, and zinc

Attachment S4B figures for the South Yard Area include only DGI data, as a more recent dataset is not available in this area.

4.2 Soil and Groundwater COC Groupings

The main body of the CMS summarizes contaminated soil and groundwater conditions site-wide for 11 constituent groups representing similar COCs (COC groups). The 11 COC groups represented in the Plant 2 COC summary figures are listed below. Groundwater maps presenting DGI and more recent data for individual COCs within the seven DGI study areas are provided in Attachment S4B.

		Industrial		Shoreline		
COC Group ID	**Individual Constituents in COC Group**	**Soil Direct Contact**	**Soil Leaching Pathway**	**Soil Direct Contact**	**Soil Leaching Pathway**	**Groundwater**
cVOC	TCE	-	X	-	X	X
	cDCE	-	X	-	X	X
	VC	-	X	-	-	X
BTEX	Benzene					Yes, using BTEX constituents as surrogates for GRPH
	Ethylbenzene					
	GRPH	X	X		X	
Arsenic	Arsenic	-	-	-	-	X
CuZn	Copper	-	X	-	-	X
	Zinc	-	-	-	-	X
Cyanide	Free Cyanide	X	-	-	-	Pending at PL2-615A, PL2-619A, and PL2-619B
DRPH	Diesel Range Petroleum Hydrocarbons (DRPH)	X	X	X	X	Yes, using naphthalene as a surrogate for DRPH and MoRPH
	Motor Oil Range Petroleum Hydrocarbons (MoRPH)	X	X	X	X	
	Naphthalene					
PCBs	PCBs	X	X	-	X	X
cPAHs	Benzo(a)pyrene TEQ	X	-	-	-	-
Pending COCs						
BEHP	BEHP	-	-	-	-	Pending at PL2-258A, PL2-619A, PL2-620A, and PL2-621A
Cadmium	Cadmium	-	X	-	-	Pending at PL2-615A, PL2-619A, and PL2-621A
Nickel	Nickel	-	-	-	-	Pending at PL2-621A only

BEHP, cadmium, nickel, and free cyanide have data or analytical issues (refer to Section 2.2 and Attachment S2B) and are retained as pending COCs for groundwater with specific additional

sampling and data evaluation requirements to determine if they will become COCs (refer to Table 2-1).

Soil COCs, free cyanide and cPAHs, and pending soil and groundwater COC, cadmium, are presented with the same level of data evaluation and graphical presentation as the rest of the confirmed COC groups. The pending groundwater COCs BEHP and nickel are presented after the confirmed COC groups in Section 4.0. Data evaluations for BEHP and nickel are contained in Attachment S2B; as such they do not undergo the same level of data evaluation and graphical presentations as the confirmed COC groups described in this section.

The COC group summary figures are presented as a series of maps showing soil and groundwater data in the following formats:

- Figure 4-XA (4-2A through 4-10A) – Soil data from 0 to 1 feet bgs compared to soil FMCLs.
- Figure 4-XB (4-2B through 4-10B) – Soil data from 1 to 6 feet bgs compared to soil FMCLs.
- Figure 4-XC (4-2C through 4-10C) – Soil data from 6 to 11 feet bgs compared to soil FMCLs and to the leaching SLs coordinated with A -Level groundwater FMCL exceedance areas.
- Figures 4-XD and 4-XE (4-2D/2E through 4-10D/10E) – Groundwater FMCL exceedance areas from the A-, B-, and C -Levels of the aquifer for South Plant 2 and North Plant 2, respectively.

Groundwater data for pending COCs are presented by DGI study area in Attachment S4B.

The coordinated soil and groundwater data figures present areas of impacted A-Level groundwater (COC concentrations exceeding groundwater FMCLs) with soil sample data for the 6 to 11 feet bgs sample interval exceeding FMCLs or the leaching SLs. The combined soil and groundwater figures demonstrate whether soil exceeding the leaching SL is co-located with impacted groundwater. This illustrates areas where soil located at or near the water table might affect shallow A-Level groundwater.

Groundwater data evaluations focus on areas of FMCL exceedances that reach or potentially reach the groundwater POC, which is the point at which groundwater FMCLs must be met to achieve compliance as described in Section 2.4.4.

The following sections present the site's current conditions, descriptions, and summaries of the nature and extent of FMCL exceedances in soil and groundwater for the 11 COC groups. As a reminder to support the reader for the discussion presented in Sections 4.3 through 4.13, FMCLs are currently "proposed." When approved by USEPA, these proposed FMCLs will become the "final" media cleanup levels for the corrective measures. Sections 4.3 through 4.10, and 4.11.2 are supported by maps and summary tables.

4.3 Chlorinated Volatile Organic Compounds

The constituent group cVOCs consists of the parent compound TCE, and two of its degradation compounds: cDCE and VC. The presence of cVOCs in soil and groundwater at Plant 2 is most commonly attributable to releases from the vapor degreasers or from the product piping and underground storage tanks (USTs) associated with the vapor degreasers. TCE was the most

commonly used degreasing compound at Plant 2 and, as a result, TCE and its degradation products are the most common and widespread organic COCs at Plant 2. Therefore, many of the individual COCs included in the cVOC grouping have FMCL exceedances that are co-located in the same geographic area. The cVOC group has similar physical characteristics for transport, migration, and response to remedial technologies, and are amenable to the same remedial technologies.

The cVOC group contains constituents that are COCs for groundwater (Table 2-4). The extent of cVOC constituents in soil exceeding FMCLs is limited (Figures 4-2A, 4-2B, and 4-2C). TCE is the only cVOC detected with concentrations exceeding its soil FMCLs at Plant 2. TCE was detected at only five locations exceeding its FMCLs in soil. cVOC constituents did not become soil COCs based on their limited FMCL exceedances (Tables 2-6 through 2-9). However, cVOC constituents were detected in the 6 to 11 feet bgs interval at concentrations that exceed their respective leaching SLs. cVOC constituents became soil COCs based on the leaching pathway evaluation performed in this section.

Figures 4-2B and 4-2C identify soil samples that exceed the FMCLs for cVOCs. TCE concentrations in the paved industrial area exceed the industrial FMCL at four locations (PL2-SSL2, PL2-212A, PL2-212B, and PL2-209A); these locations are associated with the AOC 2-10.3A (North TCE Degreaser) and AOC 2-10.4A (South TCE Degreaser) sheetpile structures and are identified as purple symbols in Figures 4-2B and 4-2C. TCE was detected at one location (P2IM-SM-05) in the unpaved shoreline area at concentrations exceeding the shoreline FMCL, and identified as an orange symbol in Figure 4-2C. Soil in this area was removed to 11 feet bgs during the site redevelopment for the construction of Plant 2 stormwater system bioswales.

Groundwater with cVOC concentrations exceeding FMCLs in the A-, B-, and C-Levels of the aquifer is depicted as 16 individual or groupings of exceedance areas identified as cVOC-1 through cVOC-16 as shown in Figures 4-2D and 4-2E. The relationship between soil and groundwater exceedances indicates that the presence of cVOCs in A-Level groundwater at concentrations exceeding FMCLs is likely related to cVOC present in vadose-zone soils (see areas cVOC-1, cVOC-5, cVOC-10, cVOC-13, and cVOC-15 in Figure 4-2C). Groundwater conditions, based on DGI or more recent data, for each of the 16 cVOC areas with FMCL exceedances are summarized in Table 4-1.

Figure 4-2C identifies soil samples that exceed the leaching SLs for cVOCs and areas where groundwater is impacted for cVOCs. In general, soil cVOC concentrations in the 6 to 11 feet bgs interval that exceed the leaching SLs coincide with cVOC-impacted groundwater in the A-Level of the aquifer. Therefore, cVOCs (TCE, cDCE, and VC) are COCs for soil based on the leaching pathway. Impacted A-Level groundwater areas associated with co-located soil exceedances are:

- cVOC-1 (SWMU 2-89.68, Reclamation Yard and SWMU 2-91.70, Deactivated Waste Oil and Coolant Hold Area)
- cVOC-5 (OA 1, Building 2-66 Southwest and OA 11, Building 2-72 Area)
- cVOC-10 (SWMU 2-31.18, Area B Acid Waste Hold Tank and SWMU 2-41.33, Deactivated Anodic Tank Line)

- cVOC-13 (AOC 2-10.4A, South TCE Degreaser)
- cVOC-15 (AOC 2-10.3A, North TCE Degreaser)

More detailed maps depicting sampling locations and concentrations of the individual cVOCs TCE, cDCE, and VC in the DGI study areas are presented in Attachment S4B.

4.4 Benzene, Toluene, Ethylbenzene and Xylene and Gasoline-Range Petroleum Hydrocarbons

The BTEX/GRPH COC group includes the COCs benzene, ethylbenzene, and GRPH. BTEX constituents are components of fuel and therefore, it is common for the individual BTEX constituents and GRPH to have soil FMCL exceedances that are co-located in the same geographic area. The presence of BTEX and GRPH in soil and groundwater at Plant 2 is most commonly attributable to releases from GRPH product piping, aboveground storage tanks (ASTs), and USTs associated with fueling operations at Plant 2. BTEX constituents are the most mobile components of GRPH fuels and will be used as surrogates for determining compliance with FMCLs for GRPH in groundwater because there are no surface water criteria for GRPH (refer to Section 2.4.2). To be considered in compliance, all BTEX compounds (i.e., benzene, ethylbenzene, toluene, and xylenes) must meet their groundwater FMCLs, even though only benzene and ethylbenzene became Plant 2 COCs based on current site data (Table 2-4). In soil and groundwater, BTEX and GRPH are amenable to the same remedial technologies.

None of the BTEX constituents became soil COCs in Section 2.0 based on the direct contact pathway (Tables 2-6 or 2-7). BTEX constituents were not detected in soil samples from the 0 to 11 feet bgs interval at concentrations exceeding their respective soil FMCLs in the paved industrial or unpaved shoreline areas (Figures 4-3A, 4-3B, and 4-3C). In the unpaved shoreline area, GRPH was detected in soil at location P2IMSM-05 at concentrations greater than its FMCL (Figure 4-3C); GRPH does not currently exceed its FMCL in the paved industrial or unpaved shoreline areas at any other location (Figures 4-3A, 4-3B, and 4-3C).

A leaching evaluation was performed for GRPH in both the paved industrial area and the unpaved shoreline area. Spatial evaluations of soil and groundwater exceedances conducted in subsequent paragraphs, which are shown on Figure 4-3C, establish that GRPH is a soil COC based on the leaching pathway. In the paved industrial area, GRPH was detected in soil samples from five locations in the 6 to 11 feet bgs interval at concentrations greater than the leaching SLs. The GRPH exceedances of the leaching SL correspond with GRPH-impacted groundwater in the A-Level of the aquifer only at BTEX-3 in OA 11, Building 2-72 Area.

Though BTEX constituents are not considered the source to groundwater, elevated concentrations of two BTEX constituents (benzene and ethylbenzene) are near areas with groundwater impacted by GRPH. In addition, benzene, ethylbenzene, or GRPH exceeds the leaching SL for soil in 12 locations on site.

In these cases, soil with elevated concentrations of BTEX constituents or GRPH might be addressed as part of proposed groundwater remedies. Impacted A-Level groundwater areas associated with co-located soil exceedances are as follows:

- BTEX-2 (adjacent to SWMU 2-91.70, Deactivated Waste Oil and Coolant Storage Area, and SWMU 2-78.1, Oil/water Separator)

- BTEX-3 (OA 11, Building 2-72 Area)
- BTEX-7 (adjacent to OA 18, Building 2-40 East Parking Lot Area)

In addition, BTEX exceedances in groundwater at BTEX-4 (Diesel Recovery Area) and BTEX-5 (OA 9, Former USTs PL-16, 17, and 18) represent areas where BTEX and GRPH-impacted vadose-zone soil was removed during the 2010-2012 site demolition/redevelopment but some residual groundwater impacts may remain.

Groundwater with BTEX or GRPH concentrations exceeding FMCLs in the A- and B-Levels of the aquifer is depicted as eight separate areas identified as BTEX-1 through BTEX-8, which are shown in Figures 4-3D and 4-3E. There are no FMCL exceedances for BTEX or GRPH in the C-Level of the aquifer. Groundwater conditions, based on DGI or more recent data, for each of the eight areas with FMCL exceedances for BTEX or GRPH are summarized in Table 4-2.

Maps depicting sampling locations and concentrations of the individual BTEX constituents, benzene and ethylbenzene and GRPH in the DGI study areas are presented in Attachment S4B.

4.5 Arsenic

Arsenic data are presented separately from data for other inorganic COCs, because the presence of arsenic in groundwater at concentrations exceeding its FMCL of 8.0 µg/L at Plant 2 is commonly caused by reducing geochemical conditions rather than by elevated arsenic concentrations in deeper vadose-zone (6 to 11 feet bgs) soils. Arsenic (total) is a COC for groundwater only (Table 2-4). Arsenic is not identified as a soil COC in Section 2.0 (Tables 2-6 and 2-7). Concentrations of arsenic were detected at a concentration exceeding FMCLs in a single soil sample. Spatial evaluations of soil and groundwater exceedances conducted in subsequent paragraphs establish that arsenic is not a soil COC based on the leaching pathway which corresponds with Table 2-8.

Arsenic was not detected in soil samples from the 0 to 1 and 6 to 11 feet bgs intervals at concentrations exceeding the soil FMCL in either the industrial or unpaved shoreline areas (Figures 4-4A and 4-4C). Arsenic was only detected in one soil sample at a concentration that exceeded the FMCL collected from shallow soils at OA 6 (Jet Fuel Tanks). The sample location (PL2-201B) is shown as a purple symbol in Figure 4-4B.

Arsenic was detected at concentrations greater than the leaching SL at a single sample in the 6 to 11 feet bgs interval. This sample location is within the paved industrial area in the atrium area of the 2-25 Building; it is shown on Figure 4-4C as a yellow symbol. Because arsenic concentrations do not exceed the leaching SLs, FMCL exceedances for arsenic in groundwater are not the result of a surface release or the presence of a vadose-zone soil source.

Arsenic has a complex solubility and leaching behavior as a function of the redox conditions of the groundwater (for example, see Chapters 7 and 10 in Stumm and Morgan 1970; Welch and Stollenwerk 2003). The presence or absence of DO and other sources or sinks of electrons in the groundwater controls redox conditions. In well-oxygenated groundwater, arsenic is poorly soluble; however, as the oxygen content of the groundwater decreases, naturally occurring manganese, and then arsenic, begins to leach from the aquifer matrix and dissolve into the groundwater.

Geochemically reducing low DO conditions are common in wetlands, flood plains, alluvial aquifers, and other environments where degradation of naturally-occurring plant and animal organic materials occurs in the subsurface. The Duwamish Valley, where Plant 2 is located, has contained each of these micro-environments throughout its history.

Groundwater with arsenic concentrations exceeding FMCLs is depicted as numerous separate areas on Figure 4-4C, many of which are small single-location occurrences or are located so far upgradient of the POC that they do not warrant significant evaluation. Arsenic exceedance areas are identified as Arsenic-1 through Arsenic-14, as shown in Figures 4-4D and 4-4E. Groundwater conditions, based on DGI or more recent data, for each of the 14 areas with FMCL exceedances for arsenic are summarized in Table 4-3.

Groundwater close to the Duwamish Waterway is generally more oxygenated than groundwater farther upgradient at Plant 2 because tidal cycles in the Duwamish Waterway cause significant groundwater level fluctuations that oxygenate groundwater near the waterway. The tidally influenced groundwater level fluctuations alter geochemical conditions to be more aerobic, which results in lower solubility for arsenic at sampling locations near the waterway. As a result, areas near the waterway are not generally impacted by arsenic, with the possible exceptions of Arsenic-3, Arsenic-7, Arsenic-8, and Arsenic-9 as shown in Figures 4-4D and 4-4E and as noted in Table 4-3.

More detailed maps depicting sampling locations and concentrations of arsenic in the DGI study areas are presented in Attachment S4B.

4.6 Copper and Zinc

Copper and zinc were grouped together because both are common metals that have been detected at concentrations greater than their respective FMCLs in groundwater without an apparent release mechanism. Copper and zinc were not grouped with arsenic because the mechanism causing elevated arsenic concentrations in groundwater (i.e., increased arsenic solubility due to reducing redox conditions) differs from the likely mechanisms causing elevated concentrations of copper and zinc in soil and groundwater.

Copper and zinc are both COCs for groundwater (Table 2-4). Neither copper nor zinc were detected in soil samples from the 0 to 11 feet bgs interval at concentrations exceeding their respective FMCLs in either the paved industrial or unpaved shoreline areas (Figures 4-5A, 4-5B, and 4-5C). Neither constituent is identified as a soil COC in Section 2.0 (Tables 2-6 and 2-7).

Copper exceeds the leaching SL for soil in four locations dispersed across the paved industrial area (Table 2-8) and zinc exceeds the leaching screening level in one location. Copper and zinc were not retained for evaluation with respect to the leaching pathway in the unpaved shoreline area (Table 2-9). Zinc was not retained for evaluation with respect to the leaching pathway in the paved industrial area (Tables 2-8).

Copper was detected in soil samples at four locations in the 6 to 11 feet bgs interval at concentrations greater than its respective leaching SLs (zinc was detected at one location at a concentration greater that it's leaching SL). These soil sample locations are shown in Figure 4-5C as yellow symbols in the paved industrial area. The spatial relationship between copper or zinc in soil (6 to 11 feet bgs) and A-Level groundwater is shown in Figure 4-5C. With only one exception (OA 6, Northeast Area), copper concentrations in soil in the 6 to 11 feet bgs interval

that exceed the leaching SLs do not coincide with copper groundwater exceedance areas in the A-Level of the aquifer (Figure 4-5C). The coordinated soil and groundwater figure shows that in general, areas of FMCL exceedances for copper in groundwater do not have an identified vadose-zone soil source and therefore, copper (not zinc) is not a soil COC for the leaching pathway.

The lack of correlation between FMCL exceedances in groundwater and leaching SL exceedances in soil indicates that the presence of copper and zinc in A-Level groundwater at concentrations exceeding FMCLs is likely related to factors other than copper and zinc source material in vadose-zone soil. Possible causes of elevated copper and zinc concentrations in groundwater samples include sample turbidity (common in direct push probe samples) and matrix interference issues (as outlined in Section 2.2 and Attachment S2B).

The largest copper or zinc exceedance areas are CuZn-1, CuZn-3, CuZn-5, and CuZn-10. Unlike arsenic, which is associated with reducing geochemical conditions, the CuZn exceedance areas do not appear to have a common set of conditions that are responsible for their presence. An evaluation of the data indicates there are different conditions in each area that are likely responsible for the elevated copper or zinc concentrations in the samples. The conditions likely affecting the four largest CuZn exceedance areas are presented below:

- CuZn-1: Elevated zinc concentrations in two newly installed B-Level wells likely caused by disturbed aquifer conditions remaining from well installation and development.
- CuZn-3: Elevated copper concentrations in some A-Level wells and probes co-located with the cVOC plume in the 2-60s Area. Copper concentrations in CuZn-3 range from 8.5 to 21 µg/L with most only slightly greater than the proposed FMCL of 8.0 µg/L. There does not appear to be a correlation to turbidity or geochemical conditions for CuZn-3. Geochemical conditions are generally reducing throughout this area and most probe samples have high turbidity but there are only a few minor exceedances of the copper proposed FMCL.
- CuZn-5: Elevated copper concentrations in some A-Level wells and probes co-located with the cVOC plume in the 2-60s and 2-66 Areas. Copper concentrations in CuZn-5 range from 8.3 µg/L to 74.6 µg/L with most only slightly greater than the proposed FMCL. There does not appear to be a correlation to turbidity or geochemical conditions for CuZn-5. Geochemical conditions are generally reducing throughout this area and most probe samples have high turbidity but there are only a few minor exceedances of the copper proposed FMCL.
- CuZn-10: Elevated zinc concentrations in B-Level probe samples co-located in an area with a large A-Level and a smaller B-Level cVOC exceedance area. CuZn-10 is based solely on seven B-Level probe results. None of the A-Level samples from the seven probes have a detection for zinc, nor do additional A-Level only probes indicating that elevated zinc is likely attributable to high turbidity samples from probes sampled in the lower permeability B-Level of the aquifer.

Groundwater with copper and zinc concentrations exceeding FMCLs is depicted as numerous separate areas, many of which are small single-location occurrences or are located far upgradient of the POC. Some of the small single-location areas are grouped together because they do not warrant significant evaluation as shown in Figures 4-5D and 4-5E. Copper and zinc exceedance areas are identified as CuZn-1 through CuZn-23 as shown in Figures 4-5D and 4-5E.

Groundwater conditions, based on DGI or more recent data, for each of the 23 CuZn FMCL exceedance areas are summarized in Table 4-4.

More detailed maps depicting sampling locations and concentrations for copper and zinc in the DGI study areas are presented in Attachment S4B.

4.7 Cyanide

Cyanide is the only non-metal inorganic constituent in the list of COCs for soil and groundwater. The constituent's chemistry is more complicated than most of the other COCs because cyanide forms complexes with various metals that can be strong or weak depending on which metal forms the complex. There are three classes of cyanide complexes; total cyanide, WAD cyanide, and free cyanide. Each one of these classes has a different analytical method that quantifies results that represent a distinct fraction of cyanide complexation as described in Section 2.0.

The cyanide FMCL for groundwater was developed for the free cyanide fraction. The cyanide data collected during the DGI data represents total cyanide (early DGI data) or WAD cyanide (later DGI data). As a result, there is a significant potential that the areas identified as having cyanide FMCL exceedances represent false positives because the noted analytical methods used during the DGI concentrations include cyanide complexes that are not applicable to the FMCL for free cyanide. Because of this, cyanide became a pending groundwater COC only at locations downgradient or closely cross gradient of areas where historical data exceeds the groundwater FMCL (Tables 2-1 and 2-4).

In the paved industrial area, free cyanide became a soil COC for the direct contact pathway (Table 2-6) because it was detected at concentrations up to 10 times greater than the FMCL in seven samples. These predominantly occur in shallow soils; in soils from the 6 to 11 foot bgs depth interval, only one sample exceeds the leaching SL (Table 2-8). In the unpaved shoreline area, free cyanide did not become a soil COC for either the direct contact or leaching pathways (Tables 2-7 and 2-9). Spatial evaluations of soil and groundwater exceedances conducted in subsequent paragraphs establish that free cyanide is potentially a soil COC based on the leaching pathway, but will be addressed with locations that exceed FMCLs.

Within the paved industrial area, free cyanide was detected in soil at concentrations above FMCLs at two locations in the 0 to 1 feet bgs interval (Figure 4 6A). Free cyanide was detected in soil, at concentrations above FMCLs at four locations in the 1 to 6 feet bgs interval and one location in the 6 to 11 feet bgs interval in the paved industrial area (Figure 4-6B). These sample locations are located within OA 18, Building 2-40 East Parking Lot Area and the southwest portion of the 2-10 Building and are identified as red symbols in Figures 4-6A and 4-6B.

Based on DGI data, cyanide has only been detected at concentrations greater than its groundwater FMCL (1.0 µg/L) at three locations in A-Level groundwater, designated Cyanide-1 through Cyanide-3. Soil free cyanide concentrations in the 6 to 11 feet bgs interval that exceed the leaching SLs coincide with free cyanide-impacted groundwater in the A-Level of the aquifer at one location (Cyanide-3 in Figure 4-6C). This indicates a potential soil source to groundwater near OA 18, Building 2-40 East Parking Lot Area.

Groundwater with concentrations of free cyanide exceeding the cyanide FMCL in the B-Level of the aquifer is depicted as three separate exceedance areas, identified as Cyanide-4 and

Cyanide-6, shown in Figures 4-6D and 4-6E. Groundwater conditions, based on DGI data, for the six cyanide FMCL exceedance areas are summarized in Table 4-5.

More detailed maps depicting sampling locations and concentrations separately for free cyanide in the 2-60s, 2-66, and 2-40s DGI study areas are presented in Attachment S4B.

4.8 Diesel- and Motor Oil-Range Petroleum Hydrocarbons, and Naphthalene

DRPH and MoRPH were grouped together because they are both heavy-end carbon chain fuels and therefore, they are commonly released by the same mechanisms. Naphthalene is also part of this group because it is a mobile component of diesel and oil. All three of these constituents have similar physical characteristics for transport, migration, and response to remedial technologies. The presence of DRPH, MoRPH, and naphthalene in groundwater at Plant 2 is most commonly attributable to releases from the product piping and USTs associated with fueling operations. BTEX and naphthalene are the most mobile components of fuels and will be used as surrogates for determining compliance with FMCLs for DRPH and MoRPH in groundwater because there are no surface water criteria for these fuels (refer to Section 2.4.2). To be considered in compliance, naphthalene and all BTEX constituents must meet their groundwater FMCLs. However, only DRPH, MoRPH, and naphthalene data will be used to evaluate current conditions.

DRPH, MoRPH, and naphthalene are COCs for groundwater (Table 2-4). DRPH and MoRPH (but not naphthalene) are soil COCs for the direct contact pathway in the paved industrial area (Table 2-6). Only MoRPH is a soil COC for the direct contact pathway in the unpaved shoreline area (Table 2-7). A leaching evaluation was performed for DRPH and MoRPH in both the paved industrial area and the unpaved shoreline area (Tables 2-8 and 2-9). Spatial evaluations of soil and groundwater exceedances conducted in subsequent paragraphs, which are shown on Figure 4-7C, establish that DRPH and MoRPH are soil COCs based on the leaching pathway in the paved industrial area and the unpaved shoreline area.

In the paved industrial area, DRPH and MoRPH were detected sporadically across the site in 10 locations from the 0 to 11 feet bgs interval at concentrations exceeding their respective soil FMCLs. These soil sample locations are identified as red symbols in Figures 4-7A, 4-7B, and 4-7C. Naphthalene was only detected in two soil samples at a concentration that exceeded the FMCL; these samples were collected from shallow soil in the 1 to 6 feet bgs interval at OA 18 (Building 2 40 East Parking Lot Area). The sample locations are shown as purple and red symbols in Figure 4-7B. In the 6 to 11 feet bgs interval, DRPH or MoRPH exceed the leaching SL for soil in 8 locations on site (Figure 4-7C). These soil sample locations are located throughout the paved industrial area and identified as yellow symbols in Figure 4-7C.

In the unpaved shoreline area, DRPH and MoRPH were detected at one location in the 6 to 11 feet bgs interval at concentrations greater than the FMCL and leaching SL. This location (P2IM-SM-05) is identified as an orange symbol in Figure 4-7C.

The extent of naphthalene in groundwater exceeding FMCLs is limited to two locations in the A-Level of the aquifer. Neither naphthalene groundwater exceedance area corresponds to the three locations where soil samples from the 6 to 11 feet bgs interval exceed the leaching pathway criteria. These three areas are identified as yellow symbols in Figure 4-7C. Therefore, there is no demonstrated leaching of naphthalene from soil to groundwater and naphthalene is not identified as a soil COC in Section 2.0 (Tables 2-6 and 2-7).

In general, soil DRPH and MoRPH concentrations in the 6 to 11 feet bgs interval that exceed the leaching SLs, coincide with DRPH- and MoRPH-impacted groundwater in the A-Level of the aquifer (Figure 4-7C). This strong relationship indicates that the presence of DRPH and MoRPH in A-Level groundwater at concentrations exceeding its FMCL is likely related to DRPH and MoRPH releases to vadose-zone soils (see areas DRPH-2, DRPH-4, and DRPH-6 in Figure 4-7C), which confirms DRPH and MoRPH are soil COCs based on the leaching pathway. Impacted A-Level groundwater areas associated with co-located soil exceedances are as follows:

- DRPH-2 (SWMU 2-91.70, Deactivated Waste Oil and Coolant Hold Area)
- DRPH-4 (OA 11, Building 2-72 Area)
- DRPH-6 (SWMU 2-41.31, Machine Pits and UST PL-55)

Groundwater with DRPH, MoRPH, or naphthalene concentrations exceeding FMCLs in all levels of the aquifer is depicted as seven separate areas as shown in Figures 4-7D and 4-7E and identified as DRPH-1 through DRPH-7. Groundwater conditions, based on DGI data, for the seven DRPH FMCL exceedance areas are summarized in Table 4-6.

More detailed maps depicting sampling locations and concentrations separately for DRPH, MoRPH, and naphthalene in the South Yard, 2-66, 2-40s, 2-10, and North DGI study areas are presented in Attachment S4B.

4.9 Polychlorinated Biphenyls

PCBs were used in transformers located in the tunnel system beneath buildings in the 2-40s Area and in hydraulic oil associated with manufacturing machines and equipment at Plant 2.

PCBs are a groundwater COC. PCBs are soil COCs based on the direct contact pathway in the paved industrial area, but not in unpaved shoreline area (Tables 2-6 and 2-7). In both the paved industrial area and the unpaved shoreline area, PCBs exceed the leaching SL (Tables 2-8 and 2-9). Spatial evaluations of soil and groundwater exceedances conducted in subsequent paragraphs establish that, PCBs are a likely source of contamination to groundwater based on the leaching pathway in the paved industrial area.

Ongoing IMs have addressed much of the PCB contamination at Plant 2 in both the paved industrial area and the unpaved shoreline area. In the paved industrial area, PCB contamination exceeding the soil FMCL remains in only one sample from the 0 to 1 foot bgs interval. This soil sample location is identified as a red symbol in Figure 4-8A. No samples exceeding the soil FMCL for PCBs remain in the unpaved shoreline area.

Locations where PCBs were detected at concentrations greater than the leaching SL in soil samples from 6 to 11 feet bgs interval are identified as yellow symbols in Figure 4-8C. Soil PCB concentrations in the 6 to 11 feet bgs interval that exceed the leaching SLs coincide with PCB-impacted groundwater in the A-Level of the aquifer at one location in the paved industrial area. The spatial relationship between PCBs in soil (6 to 11 feet bgs) and A-Level groundwater is demonstrated in Figure 4-8C. This relationship indicates that the presence of PCBs in A-Level groundwater at concentrations exceeding FMCLs is likely related to PCB releases to vadose-zone soils (see area PCB-1 in Figure 4-8C).

The TMCL for total PCBs in groundwater is equivalent to the November 2016 Washington Clean Water Act-Effective criterion of 0.000007 µg/L, which is far below the PQL that can be achieved with the current laboratory method for PCBs. At Plant 2, groundwater has been analyzed for total PCBs as Aroclors using USEPA Method 8082, which has a PQL of 0.1 µg/L. Therefore, the proposed FMCL for total PCBs is 0.1 µg/L.

The use of the PQL-based TMCL has reduced the number of identified PCB exceedance areas in groundwater to just PCB-1, as identified on Figure 4-8D. Evaluations of the potential for PCB-impacted soil to leach PCBs to groundwater are limited by the PQL, which resulted in only one identified groundwater exceedance area for PCBs. However, there are detections for PCBs in groundwater at a method detection limit (MDL) that varies between approximately 0.0094 µg/L and 0.01 µg/L. These PCB detections, although not FMCL exceedances of the PQL-based FMCL, are useful for evaluating the potential for PCBs in soil to leach into groundwater.

In the A-Level of the aquifer, groundwater with PCB detections associated with co-located soil with concentrations greater than the leaching SL, are as follows:

- 2-60-PCB-A2 (SWMU 2-62.46, Paint Booth Sump)
- 2-40-PCB-A1 (OA 21, Building 2-44 Machine Shop Area)
- 2-31-PCB-A1 (This area is inside Building 2-25 and is not located within a RCRA unit)

Though there are no soil samples that exceed the leaching SL in the vicinity of PCB-1, a soil IM was performed in this area to remove PCB- impacted soil. Therefore, detections of PCBs in groundwater at PCB-1 represent a potential correlation between soil and groundwater impacts for PCBs.

The Plant 2 groundwater TMCL for PCBs is based on the PQL that can be achieved using USEPA Method 8082A (0.1 µg/L; refer to Attachment S2D). Groundwater with PCB concentrations exceeding the PQL-based FMCL in all levels of the aquifer is shown on Figures 4-8D and 4-8E. There is only one PCB exceedance area in groundwater: PCB-1, identified on Figure 4-8D. Groundwater conditions, based on DGI data, for PCB-1 are summarized in Table 4-7.

More detailed maps depicting sampling locations and concentrations for PCBs in the DGI study areas are presented in Attachment S4B.

4.10 Carcinogenic Polycyclic Aromatic Hydrocarbons

Potential sources of cPAHs at Plant 2 are associated with aircraft maintenance activities, waste storage areas, urban background contamination, and treated pilings beneath structures.

cPAHs are not groundwater COCs (Table 2-4). cPAHs are COCs in soil based on the direct contact pathway in the paved industrial area, but not the unpaved shoreline area (Tables 2-6 and 2-7). Although cPAHs are present in soil at concentrations greater than the leaching SL (Tables 2-8 and 2-9), cPAHs are not a groundwater COC. Thus, groundwater data demonstrates that the leaching pathway is not causing groundwater impacts. This outcome is consistent with the high

partitioning coefficient (K_d)[11] values for cPAHs indicating their strong preference to remain adsorbed onto soil rather than partition into groundwater.

Ongoing IMs have addressed much of the cPAH contamination at Plant 2 in both the paved industrial area and the unpaved shoreline area. In the paved industrial area, cPAHs exceed the FMCL in 13 soil samples from the 0 to 11 feet bgs interval at OA 18 and near UST PL 4. These sample locations are identified as red symbols in Figures 4-9A, 4-9B, and 4-9C. In the unpaved shoreline area, cPAH contamination exceeding the FMCL has been removed.

Locations where cPAHs were detected in soil samples at concentrations greater than the leaching SLs are shown in Figure 4-9C as yellow symbols. The locations are within the paved industrial area at OA 18, Building 2-40 East Parking Lot Areas; UST PL 4; SWMU 2-41.31, Machine Pits; and OA 1, Building 2-66 Southwest.

4.11 Pending Constituents of Concern

The constituents BEHP, cadmium, and nickel exhibited analytical issues, which indicated their groundwater data sets were potentially affected by outside contaminant sources (BEHP) or by saline matrix interference (cadmium and nickel) as described in Section 2.0 and in Attachment S2B, Analytical Considerations for Groundwater Compliance. These constituents are retained as pending COCs for groundwater. Their potential inclusion in the groundwater COC list will be determined by focused evaluations performed with data from specific POC shoreline monitoring wells, as described in the following sections.

4.11.1 Bis(2-ethylhexyl)phthalate

BEHP is a common environmental contaminant attributable to plasticizers used in polyvinyl chloride (PVC) and other polymers including rubber, cellulose, and styrene. BEHP is also a common laboratory contaminant because it is present in the plastic labware, bottles, and other equipment and supplies commonly used in analytical laboratories. BEHP was detected in groundwater samples analyzed during 2008; however, these detections may represent false positives (refer to Attachment S2B).

BEHP is a pending COC for groundwater (Tables 2-1 and 2-4). BEHP is not a soil COC based on either the direct contact pathway (Tables 2-6 and 2-7) or the leaching pathway (Tables 2-8 and 2-9).

BEHP is a pending COC for groundwater at four specific shoreline monitoring wells: PL2-258A, PL2-619A, PL2-620A, and PL2-621A. Groundwater samples from these wells will be analyzed for BEHP for four semiannual shoreline monitoring events. If there are no exceedances of the proposed FMCL after the four events are completed, Boeing will evaluate the data without the use of statistics to determine that BEHP will not be retained as a COC for groundwater, and will discontinue monitoring for BEHP. If there are exceedances of the proposed FMCL, samples from the well(s) with exceedances will be analyzed for BEHP for a total of eight events. After eight

[11] The partitioning coefficient, K_d, is a ratio of the mass of a chemical adsorbed in the soil to the equilibrium chemical concentration remaining in solution. Higher K_d values indicate that a chemical displays a stronger preference for adsorption onto soil, while lower K_d values indicate a greater affinity for water. Chemicals with higher K_d values tend to be less mobile in the environment.

events are completed, Boeing will evaluate the data using the 95% UCL statistical evaluation to determine if BEHP will be retained as a COC for groundwater.

Detailed maps depicting sampling locations and concentrations for BEHP in the DGI study areas are presented in Attachment S4B.

4.11.2 Cadmium

There are no known sources of cadmium at Plant 2 resulting from Plant 2 operations. Elevated detections of cadmium might be an artifact of saline matrix interferences (refer to Attachment S2B) or placement of contaminated fill. Saline matrix interference could cause false positive results in groundwater samples from shoreline monitoring wells, especially in samples from shoreline wells that are brackish to saline due to their depth or their proximity to the waterway (e.g., shoreline wells PL2-258B, PL2-614A, PL2-619B, and PL2-621A). Field parameter data for these wells indicate they have higher measured conductivity values than other shoreline wells completed in the same level of the aquifer. Cadmium was retained as a pending groundwater COC until a sufficiently large data set is available to test this hypothesis.

Cadmium is not a soil COC based on the direct contact pathway (Tables 2-6 and 2-7). Cadmium was not detected at concentrations exceeding its FMCL in any sample collected in the paved industrial or unpaved shoreline areas (Figures 4-10A, 4-10B, and 4-10C). Cadmium was detected in the 6 to 11 feet bgs interval at concentrations greater than the leaching SLs within the paved industrial area, but not within the unpaved shoreline area (Tables 2-8 and 2-9). This section evaluates whether cadmium should become a soil COC in the paved industrial area based on the leaching pathway.

Cadmium was detected in soil samples at 13 locations at concentrations greater than the leaching SLs. These locations are shown in Figure 4-10C as yellow symbols in the paved industrial area near SWMU 2-41.33, Deactivated Anodic Tank Line; in the southeast corner of the 2-88 Building; and in the 2-10 North Sheetpile Area. Soil locations that exceed the cadmium leaching SL do not correspond to areas with impacted groundwater, with the exception of Cadmium-4 near SWMU 2-41.33. In this area, soil was excavated to a depth of 11 feet bgs to remove cVOC contamination, likely removing cadmium-impacted soil as well. The spatial relationship between cadmium in soil and A-Level groundwater at Cadmium-4 confirms that soil was a likely source of groundwater contamination based on the leaching pathway in this area.

The apparent lack of correlation between soil and groundwater exceedance areas elsewhere at Plant 2 is attributable to the removal of contaminated fill or other soil that might have historically served as a source to groundwater, which has subsequently been replaced by clean soil. This applies to exceedance areas Cadmium-1 through Cadmium-3 as noted in Table 4-8.

Based on DGI data and more recent shoreline monitoring data from August 2016, cadmium has only been detected at concentrations greater than its FMCL at five locations in groundwater. The cadmium exceedance areas are designated Cadmium-1 through Cadmium-5 and are presented in Figures 4-10C, 4-10D, and 4-10E. All five exceedance areas are in the A-Level of the aquifer. Groundwater conditions, based on DGI data, for the five cadmium exceedance areas are summarized in Table 4-8.

More detailed maps depicting sampling locations and concentrations for cadmium in the Plant 2 DGI study areas are presented in Attachment S4B.

4.11.3 Nickel

There are no known sources of nickel at Plant 2; its presence in groundwater at Plant 2 is believed to be a result of saline matrix interferences in historical analytical methods. Boeing has worked with their analytical laboratory to identify a method that mitigates this saline matrix interference, and in 2011 received approval from USEPA to adopt an analytical method that reduces the saline matrix interference (refer to Attachment S2B).

Following implementation of the improved analytical method, most shoreline wells demonstrated total nickel concentrations were less than the nickel FMCL. These results demonstrate that saline matrix interference caused false positive FMCL exceedances for much of the nickel data. However, new well PL2-621A had FMCL exceedances for total nickel in two of the six shoreline monitoring events that were completed at the time this report was prepared. Therefore, nickel was retained as a pending COC exclusively at shoreline well PL2-621A. Nickel data from PL2-621A will be evaluated after eight shoreline monitoring events are completed at PL2-621A, using the 95% UCL statistical test. Results of this statistical test will be used to determine if total nickel analysis should be discontinued at PL2-621A, or if the Adaptive Management process described in Section 6.3.8 for inorganics should be initiated.

In soil, concentrations of nickel do not exceed FMCLs in the 0 to 11 feet bgs interval or the leaching SLs in the 6 to 11 feet bgs interval at Plant 2. Therefore, nickel is not a soil COC based on the direct contact pathway (Tables 2-6 and 2-7) and is not retained for evaluation with respect to the leaching pathway (Tables 2-8 and 2-9). The lack of leaching SL exceedances in soil is consistent with the conclusion that FMCL exceedances for nickel in groundwater are false positives resulting from well-known and well-documented saline matrix interference issues in the standard analytical method that was used during the DGI and earlier groundwater sampling events.

Historical groundwater data with nickel concentrations exceeding its FMCL (using the older analytical method that exhibits saline matrix interference issues) occurs in numerous separate areas, many of which are small single-location occurrences or are located far upgradient of the POC and do not warrant evaluation. Detailed maps depicting sampling locations and concentrations for nickel in the Plant 2 DGI study areas are presented in Attachment S4B.

5.0 EVALUATION OF REMEDIAL TECHNOLOGIES

This section describes the screening process used for soil and groundwater remedial technologies, based on their applicability for the site-specific soil and groundwater conditions at Plant 2.

5.1 Initial Remedial Technology Screening

The first step of the screening process was to prepare a list of all potentially applicable technologies for soil and groundwater remediation at Plant 2. The list was based on a comparison of Plant 2 COC groups for soil and groundwater with the potentially applicable treatment technologies that are summarized in the Federal Remediation Technologies Roundtable's (FRTR's) Treatment Technologies Screening Matrix (FRTR 2002), which is presented in Attachment S5A. Treatment technologies that this screening matrix rates as average or above average for one or more of the Plant 2 COC groups were retained for further evaluation. Treatment technologies rated as below average or not applicable, as well as those that had insufficient data to be rated, were not retained; no further evaluation was performed for those technologies. Attachment S5A contains brief descriptions for each of the remedial technologies that were evaluated.

5.2 Remedial Technology Screening for Site-specific Conditions

The second step of the screening process was the evaluation of the retained remedial technologies considering specific Plant 2 COCs, site-specific hydrogeologic conditions, and current and future land use. Table 5-1 summarizes remedial technologies for soil and groundwater that will be carried forward for further evaluation and detailed analysis, as well as those that have been eliminated from further consideration for soil or groundwater remediation at Plant 2. Table 5-1 also presents the rationale for eliminating remedial technologies that were not retained for further evaluation.

5.3 Retained Remedial Technologies

Soil and groundwater remedial technologies remaining following the initial and site-specific screening steps are summarized in Table 5-2. These technologies represent technologies with "average" or "above average" ratings for remediation of one or more Plant 2 COCs, which are also appropriate for the site-specific conditions at Plant 2. These technologies will be used to assemble remedial alternatives in Section 6.0 of this document.

Section 4.0 describes current soil and groundwater conditions that potentially require remediation. These exceedance areas fall into three broad categories:

- **Soil Only Areas**. These areas have exceedances of FMCLs in soil only, and no associated groundwater issues.
- **Groundwater Only Areas**. These areas have exceedances of FMCLs in groundwater only, either because soil was not the original source to groundwater or because any associated soil source area was already remediated as part of an IM.
- **Combined Soil and Groundwater Areas**. These areas have exceedances of the FMCLs in groundwater (although the exceedance may not be near the POC for groundwater), and exceedances of leaching SLs in soil, which may be contributing to the on-going groundwater contamination.

In Section 6.0, these areas are grouped into RAs and assigned a unique identifier. Appropriate remedial technologies from the list above will be presented as alternatives for each of the RAs, either as stand-alone technologies or as suites of complementary technologies; suites of technologies may be implemented sequentially or at the same time, as appropriate to achieve corrective action objectives. The alternatives will then be further evaluated. In cases where an RA is limited to one media, particularly for soil only areas, remedial alternatives will commonly consist of a single technology. For some groundwater-only RAs, two or more remedial technologies will be grouped into alternatives. In all cases where both soil and groundwater potentially require remediation, the alternatives presented consist of two or more remedial technologies.

6.0 IDENTIFICATION OF REMEDIATION AREAS AND EVALUATION OF ALTERNATIVES

6.1 Remediation Area Identification

For clarity in assembling remedial alternatives, Plant 2 was divided into nine RAs with similar or contiguous hydrogeologic conditions, similar constituent groups, and exceedances of FMCLs in soil, groundwater, or in both media. Organizing Plant 2 into RAs breaks the scope of work for soil and groundwater remediation at Plant 2 into nine separate, manageable, and focused work plans that will be prepared and used to implement the selected remedial alternative for each of the RAs.

The nine RAs listed below and are further described in Tables 6-1A through 6-9A:

- RA 1 – 2-10 North Sheetpile Area
- RA 2 – 2-10 South Sheetpile Area
- RA 3 – 2-31 Area
- RA 4 – 2-66 Sheetpile and Surrounding Area
- RA 5 – South Yard Area
- RA 6 – OA 18 Area
- RA 7 – Unpaved Shoreline Area
- RA 8 – Paved Industrial Area
- RA 9 – OA 11 Area

Figures 6-1 and 6-2 show the location of each of these RAs at Plant 2; Figures 6-3A through 6-11A and 6-11B provide detailed information about soil and groundwater conditions potentially requiring remediation in each RA.

Tables 6-1A through 6-9A present detailed information about each RA, including associated RCRA units and specific sampling locations (for soil) or exceedance areas (for groundwater) where grouped COC data exceed FMCLs. For each RA, COC groups that exceed FMCLs are designated with a numerical value representing their “maximum exceedance factor,” which is calculated by dividing the highest detected concentration for that COC by its FMCL, (for petroleum hydrocarbons in groundwater only).[12]

The following sections contain summaries of applicable remedial technologies and assembled remedial alternatives for RA 1 through RA 9.

6.2 Assembly of Technologies into Alternatives

This section assembles applicable remedial technologies into potential remedial alternatives for removal, containment, and/or treatment of soil and groundwater areas that exceed FMCLs. The

[12] For petroleum hydrocarbons, FMCLs are based on surrogate criteria for BTEX and napthalene; FMCLs are not available for TPH (refer to Section 2.4.2). TMCLs for TPH are based on MTCA Method A groundwater criteria, and were used to identify exceedance areas and maximum exceedance factors.

USEPA recognizes that in situations where relatively straightforward remedial solutions are appropriate, extensive evaluation of corrective measures may not be necessary and a "focused" approach may be used. For the purposes of this document, a focused approach was used to identify potential alternatives for each RA. A focused approach does the following:

- Addresses the corrective action objectives
- Identifies appropriate, implementable remedies based on good engineering practices and experience
- Considers the extent, nature, and complexity of releases and contamination

Extensive evaluation was not performed for alternatives with technologies that are not technically feasible, easily implemented, or effective at remediating RA-specific contaminants at Plant 2.

Tables 6-1A through 6-9A include columns for each of the applicable remedial technologies for soil and/or groundwater identified in Section 5.0. Technologies potentially applicable each RA are identified with an "X" based on the technology's ability to remediate one or more of the COCs within the RA.

Tables 6-1B through 6-9B present remedial alternatives for each RA to meet the overall corrective action objectives defined in Section 1.0. For RAs with exceedances in both soil and groundwater, alternatives are comprised of multiple technologies chosen to address exceedances in both media.

6.3 Technologies Common to Many Alternatives

Some of the technologies presented in Tables 6-1A through 6-9A for RAs 1 through 9 are applicable to both soil and groundwater and are also a component of many of the remedial alternatives presented later in this section. These technologies are:

- Corrective Action Not Required with Controls
- Engineering Controls
- Institutional Controls
- Long-term Groundwater Monitoring
- Short-term Groundwater Monitoring
- Enhanced Reductive Dechlorination (ERD)
- Excavation with Off-Site Disposal

To avoid unnecessary duplication when describing these technologies for each RA, their common elements are described in the following paragraphs.

6.3.1 Corrective Action Not Required with Controls

Corrective Action Not Required with Controls is a designation that applies to areas of the site where no active remedy is proposed. As a "technology" this indicates that corrective actions are not required to be protective of human health and the environment, and may rely on natural biological/chemical degradation and attenuation. These areas would typically be contained within

the paved industrial area of the site, and may require application of engineering and institutional controls to be protective of human health and the environment. Groundwater monitoring may be needed to demonstrate long-term compliance with FMCLs (see Section 6.3.4).

6.3.2 Engineering Controls

The engineering controls applicable to Plant 2 include three types of controls: restricted site access, pavement (asphalt/concrete pavement or buildings), and surface water management. The purpose of each type of engineering control is to provide a physical barrier to prevent or minimize the potential for exposure or migration of contaminants, as follows:

- Restricted Site Access – Restricted access is intended to limit public access to the facility and is already in place at Plant 2. It includes fencing, guarded entrances, and limited (key card) access to the facility. The effect of this restriction is to limit access to industrial and office workers and short-term escorted visitors, consistent with the use of industrial FMCLs in the paved industrial areas of the site.
- Pavement and Building Slabs – Pavement includes asphalt or concrete pavement, and buildings that cover most of Plant 2. Pavement provides a physical barrier against direct contact with potentially impacted soil by workers and by wildlife. Pavement is also a component of the on-site surface water management system as described below.
- Surface Water Management – Site surface water management involves directing precipitation that falls on the site to the stormwater system, controlling surface water run-on, and eliminating erosion that can expose underlying impacted soil. With limited exceptions (e.g., minor infiltration through the paved areas and infiltration in landscaped areas), essentially all precipitation falling on the Plant 2 industrial area is directed to the site-wide stormwater- system and treated prior to discharge to the Duwamish Waterway. The intent is to limit rainfall infiltration to approximately 10 percent of annual rainfall, which can be accomplished by grading and pavement appropriate for parking lots.

The Engineering Controls remedial technology is included in all the individual alternatives presented in Sections 6.6 through 6.14. The elements of this technology are generally consistent for individual RAs; however, details specific to individual RAs will be described, as appropriate.

6.3.3 Institutional Controls

Institutional controls are applicable to the facility as a whole or to sections of the facility. These controls consist of enforceable restrictions such as environmental covenants, local ordinances, orders, and permit conditions intended to reduce the potential for human or environmental exposure to contamination by limiting land or resource use. Institutional controls for Plant 2 would be implemented as an environmental covenant that restricts land and groundwater use.

Environmental covenants are recorded legally binding restrictions on land and resource use for a parcel of property. As described in Section 2.5.1, an environmental covenant would be developed as part of the CMI Design (after the SOB) and would include the following obligations:

- Maintain property use as industrial consistent with use of industrial cleanup levels.
- Require the paved industrial area be fenced to prevent unrestricted public access.

- Require the industrial area to be paved with concrete or asphalt, or covered by buildings, with an allowance for small landscape areas per local ordinances.
- Prohibit the installation of water supply wells of any type (e.g., domestic, irrigation, industrial).
- Require the continued maintenance of long-term features of the corrective action such as groundwater monitoring wells.

Attachment S2E is a draft environmental covenant that is included as an illustrative example of what the environmental covenant for Plant 2 is expected to look like. Habitat easements for the Northern and Southern Habitat Project Areas have already been recorded and provide appropriate restrictions for those areas.

The Institutional Controls remedial technology is included in many of the individual remedial alternatives presented in Sections 6.6 through 6.14. The elements of this technology are generally consistent for individual RAs; however, details specific to individual RAs are described as appropriate.

6.3.4 Long-Term Groundwater Monitoring

Long-term groundwater monitoring will be performed at Plant 2 using three separate monitoring well networks:

- Shoreline Monitoring Well Network
- Upgradient Monitoring Well Network
- Property Boundary Well Network

The general purpose of Long-Term Groundwater Monitoring in the shoreline monitoring well network and the property boundary well network is to confirm that the corrective measures are effective. The purpose of Long-Term Groundwater Monitoring in the upgradient monitoring well network is to evaluate groundwater quality as it enters Plant 2 to detect potentially impacted groundwater that may enter from an upgradient, off-site source in the future. The scope of the Long-Term Groundwater Monitoring program will be reviewed approximately every 5 years with USEPA, and both the number of constituents monitored and the geographic extent of the locations monitored can be expected to decrease as areas of Plant 2 are remediated. Details regarding descriptions, objectives, well locations, well construction information, sampling frequency, and constituents analyzed for the three monitoring well networks are presented in Attachment S6A.

Additional monitoring and remediation wells that are not currently included in the three well networks are present or may be installed at Plant 2 in the future. These other monitoring and remediation wells have objectives other than long-term groundwater monitoring and are described in more detail in Attachment S6A and the CMI Phase Monitoring Well Installation Work Plan in Attachment S6B.

In addition to the common elements of Long-Term Groundwater Monitoring described in this section, RA-specific monitoring considerations are described in Sections 6.6 through 6.14 for RAs 1 to 9, respectively. The requirements for Long-Term Groundwater Monitoring may be driven by specific COC(s) for each RA. The analysis for specific COC(s) is reported within a suite of

compounds based on analytical method. Long-Term Groundwater Monitoring requirements for each RA are identified by a suite of compounds and will include the associated constituents:

- Inorganics include the Plant 2 metals list and minimally incorporate all metal COCs.
- VOCs include the Plant 2 VOC list and minimally include cVOCs, BTEX, and naphthalene.
- PCBs include the Plant 2 aroclors list that will be summed to report total PCBs.
- Based on detection of TPH surrogates (BTEX and naphthalene), specific TPH analyses may be requested for one or more of the specific TPH ranges including GRPH, DRPH, or MoRPH.

6.3.4.1 Short-Term Groundwater Monitoring

As described in Section 2.0, certain constituents at Plant 2 were retained as pending groundwater COCs primarily because existing data for these constituents were inadequate to characterize groundwater quality at Plant 2. This applies to BEHP, nickel, cadmium, and free cyanide, all of which were retained as pending COCs based on historical data that were collected via analytical methods that are subject to laboratory contamination and other interferences BEHP, matrix interferences (nickel, cadmium), or that do not appropriately distinguish the appropriate oxidation state of the constituent (free cyanide). As a result, Boeing proposes short-term groundwater monitoring to collect data of sufficient quality to determine whether these contaminants require further consideration and/or corrective actions. Except for cadmium, groundwater exceedances for pending COCs that are subject to data quality issues are not presented in Section 4.0 and 6.0 figures associated with each RA, and have limited data evaluations in Sections 6.6 through 6.14. These constituents are not considered primary COCs for these RAs, and discussion in the text will be limited to a description of Boeing's proposed short-term monitoring objectives and approach. Additional consideration or actions may be required if short-term monitoring results indicate that these constituents are indeed present at concentrations greater than FMCLs.

In addition to the above proposed short-term groundwater monitoring, Boeing has analyzed for PCBs in samples from A-Level shoreline monitoring wells that are downgradient of OA 11 area and the tunnels backfilled with crushed concrete (backfilling with concrete is described in Section 3.2.2); those wells are: PL2-617A, PL2-618A, PL2-619A, PL2-620A, and PL2-621A. Except for well PL2-621A, which will be analyzed for PCBs semi-annually for a total of eight events, PCB analyses in samples from those wells were performed for four events, ending with the March 2017 Shoreline Monitoring event. Under USEPA authorization Boeing has discontinued sampling at shoreline wells PL2-617A, PL2-618A, PL2-619A, and PL2-620A, which had non-detect results at concentrations less than the PQL and maximum detection limit (MDL) during four consecutive monitoring events. Additional information regarding PCB analysis is presented in the Adaptive Management for PCBs, Section 6.3.8.

Well PL2-612AR will be analyzed for total arsenic for four semiannual shoreline monitoring events. The analysis would be used to evaluate if the elevated arsenic concentrations noted in direct push probe samples upgradient of PL2-612AR (described in Section 2.2.2) are anomalous and if continued monitoring for total arsenic at PL2-612AR is warranted. Short-term monitoring at PL2-612AR is intended to evaluate if continued groundwater monitoring is warranted at this specific well rather than evaluating if continued total arsenic monitoring is warranted at Plant 2. Similarly, short-term groundwater monitoring may be appropriate for wells downgradient of other exceedance areas where samples with detected results greater than the FMCL for inorganics

were collected using probe data. In these cases, eight monitoring events will be completed to verify that the exceedances are attributable to false positives in probe data resulting from turbidity in the sample.

In addition to the common elements of Short-Term Groundwater Monitoring described in this section, RA-specific monitoring considerations are described in Sections 6.6 through 6.14 for RAs 1 to 9, respectively. The requirements for Short-Term Groundwater Monitoring may be driven by specific COC(s) or pending COC(s) for each RA. The analysis for specific COC(s) is reported within a suite of compounds based on analytical method. Short-Term Groundwater Monitoring requirements for each RA are identified by suite of compounds and will include the associated constituents:

- Inorganics include Plant 2 metals list and minimally incorporate all metal COCs and pending COCs cadmium, nickel, and free cyanide, as applicable.
- VOCs include the Plant 2 VOC list and minimally include cVOCs, BTEX, and naphthalene.
- PCBs include the Plant 2 aroclors list that will be summed to report total PCBs.
- Based on detection of TPH surrogates (BTEX and naphthalene), specific TPH analyses may be requested for one or more of the specific TPH ranges GRPH, DRPH, or MoRPH.
- BEHP includes pending COC BEHPs.

6.3.5 Enhanced Reductive Dechlorination (ERD)

ERD is an applicable remedial technology for remediation of cVOCs. Boeing historically implemented ERD at OA 12 and in the 2-66 Sheetpile. In addition, Boeing is currently implementing ERD in the 2-10 North Sheetpile, the 2-10 South Sheetpile, and the EMF Plume. Analytical data demonstrate that ERD has achieved significant reductions in contaminant concentrations and mass every time it has been implemented at Plant 2. ERD is implemented in conjunction with groundwater monitoring to demonstrate long-term compliance with FMCLs, and may be combined with other technologies to ensure the success of the remedy. This technology may be implemented in ways that are unique to individual RAs and will be described in additional detail in Sections 6.6 through 6.10 as appropriate.

6.3.6 Excavation with Off-Site Disposal

Excavation with off-site disposal of excavated soil is an applicable remedial technology for remediation of areas where soil contamination exceeds FMCLs or may be contributing to groundwater impacts. Soil excavation may also be proposed to decrease groundwater restoration timeframes. Excavation may be coupled with additional technologies (i.e., ERD or air sparging) to achieve groundwater FMCLs. Excavation depths are anticipated to range from 1 to 11 feet bgs.

Excavated soil will be characterized prior to treatment or disposal and be loaded directly into the transport vehicles from the excavation or from temporary stockpiles. Excavated areas will remain open and secured until confirmation sampling results have been evaluated. If initial sampling results indicate that FMCLs are not met additional excavation and sampling will be performed in the specific areas that do not meet FMCLs until they are met. When confirmation samples demonstrate soil FMCLs have been met, the excavated area would be backfilled with clean fill to a pre-designed grade. Backfill would be placed in lifts and compacted to a compaction level within a defined moisture content range as specified in engineered design specifications. For

excavations not within the footprint of buildings or required landscaped areas, pavement meeting the requirements of the environmental covenant will be placed over the excavated area after the excavation is backfilled and graded.

Excavated soil will be sampled and characterized to determine disposal requirements (e.g., Subtitle C or D landfill). Although Boeing does not expect excavated soil to require incineration, thermal desorption, or any other type of treatment to meet land disposal requirements, any treatment required would be conducted off site (typically at the landfill site).

The implementation of this technology as it pertains to individual RAs will be described in Sections 6.6 through 6.14 as appropriate.

6.3.8 Adaptive Management Process for Groundwater COCs

Adaptive Management is a strategy for anticipating conditions or gathering information that may be needed to support future corrective action decisions when there is insufficient information currently available to make such a final decision or when there is a potential to significantly revise a final decision. In the case of Boeing Plant 2, Adaptive Management may be needed to address potential inorganic, organic, or PCB exceedance areas in groundwater. It requires consideration of the risk, uncertainty, and dynamics of conducting cleanup. It includes selection of appropriate measures that will ensure that cleanup goals are achieved. Subject to obtaining the advanced approval of USEPA, Adaptive Management may be applied to any of the corrective action options for Boeing Plant 2.

Adaptive Management for Inorganic COCs: The Adaptive Management process may be appropriate for certain inorganic COCs in groundwater. Some inorganic COCs, such as arsenic, are naturally occurring in soil and are more soluble and mobile in groundwater under geochemically reducing (anaerobic) conditions in the aquifer (refer to Section 4.5). Groundwater at Plant 2 that is impacted by organic constituents (predominantly cVOCs) commonly exhibits reducing geochemical conditions resulting from bacterial degradation of the organic constituents, which uses the available DO in groundwater causing or increasing reducing geochemical conditions in the area affected, resulting in elevated concentrations in groundwater of some inorganic COCs naturally-occurring in soils. In these cases, it is anticipated that the aquifer will return to natural geochemical conditions. If the aquifer does not return to its natural geochemical condition within a reasonable timeframe, Adaptive Management may be necessary for inorganics where compliance with the inorganic FMCL in groundwater is contingent on achieving organic cleanup levels. Once approval is granted by USEPA, the Adaptive Management process for inorganic COCs will be closely coordinated with USEPA and is shown graphically on Figure 6-12.

The initial step of the cleanup process for inorganics is to implement corrective measures to decrease measured organic COC concentrations to levels that are equal to or lower than their respective FMCLs. Cleanup of the organic COCs will allow the aquifer in that corrective action area to return to natural geochemical conditions. Natural geochemical conditions are anticipated to be more aerobic with higher DO concentrations and more neutral oxidation-reduction potential measurements in groundwater. POC monitoring wells in the corrective action area will continue to be monitored for inorganic COCs and aquifer state parameters (e.g., oxidation/reduction potential) under the ongoing shoreline monitoring program for an additional eight sampling events following attainment of organic FMCLs. These eight additional sampling events will establish a sufficiently large data set of inorganic COC data collected under natural geochemical conditions for statistical evaluation using the 95% confidence limit. If the natural geochemical conditions are

not met within a reasonable timeframe, Adaptive Management is expected to be necessary to evaluate what additional corrective action may be needed to ensure compliance with FMCLs.

Adaptive Management for Organic COCs: Similarly, the Adaptive Management process may be appropriate for certain organic COCs in groundwater. Proposed corrective action anticipated to reduce groundwater concentrations for these organic COCs to levels below their FMCLs; however, the timeframe for achieving FMCLs is currently unknown. Some organic COCs, particularly TCE and VC, have proposed FMCLs that are sufficiently low to cause concern there might be some POC locations that do not achieve or consistently maintain FMCLs over time. Therefore, if FMCLs are not met and maintained in a reasonable timeframe, Boeing might propose an Adaptive Management strategy for these organics to evaluate what additional or different corrective actions may be necessary to comply with the FMCLs. The Adaptive Management process for organic COCs is shown graphically on Figure 6-13.

Adaptive Management for PCBs: The TMCL for total PCBs is equivalent to the November 2016 Washington Clean Water Act-Effective criterion of 0.000007 µg/L, which is below the PQL that can be achieved with Boeing's current laboratory method. At Plant 2, groundwater has been analyzed for total PCBs as Aroclors using USEPA Method 8082A, which has a PQL of 0.1 µg/L and a MDL that varies between approximately 0.0094 and 0.01 µg/L.

For total PCBs analysis: Boeing will continue to analyze for PCB Aroclors in groundwater using USEPA Method 8082A and will compare those data to the PQL of 0.1 µg/L POC well PL2-621A, which had PCBs sporadically detected at concentrations greater than the MDL but less than the PQL, will be subject to continued monitoring, and may become a potential candidate for the Adaptive Management process. Boeing may temporarily discontinue sampling at shoreline wells PL2-617A, PL2-618A, PL2-619A, and PL2-620A, which have non-detect results at concentrations less than the PQL and MDL during four consecutive monitoring events.

In the future, Boeing will perform groundwater analysis for PCBs using a high-sensitivity analytical method (e.g., USEPA Method 1668) to achieve reporting limits closer to, or less than, the WQS. Implementation of this requirement is expected to be timed consistent with implementation of a similar requirement for other areas within the Lower Duwamish Waterway Superfund Site. However, there are technical and regulatory challenges and uncertainties associated with interpretation of data collected with high-sensitivity PCB analysis methods that preclude Boeing from adopting the analytical method for current groundwater analysis. For example, Boeing is a party in the Lower Duwamish Waterway Superfund Site, which will require remediation for PCBs, and which is being jointly managed by USEPA and Ecology. As such, any future requirements for PCB monitoring, data evaluation, and response will be developed in coordination with requirements for the Lower Duwamish Waterway Site, on the basis that there are uncertainties in how to interpret and apply USEPA Method 1668 data, as discussed in the following paragraph.

Recent data collection efforts using USEPA Method 1668 show that PCBs are detected in groundwater and surface water at concentrations above the TMCL for samples from locations throughout the Lower Duwamish Waterway (Leidos 2017). This study also indicated that blank contamination might cause a positive bias (increased PCB concentrations) to the reported results. When USEPA requires Boeing to implement a high-sensitivity analytical method that can achieve a lower PQL, USEPA may also require Boeing to resume sampling at wells with prior PCB detections and where sampling had previously been discontinued because of non-detect low-sensitivity results during 4 events.

As new data become available, Boeing will work in coordination with and subject to USEPA approval to develop and implement revised requirements and work activities within an adaptive management framework for sampling requirements, data evaluation and corrective action technology determinations. Because specific steps and schedules to establish PCB monitoring and data evaluation requirements that ensure compliance with the current surface water quality standard at the point of compliance for groundwater discharge to surface water cannot be practicably established at this time, the Adaptive Management process for PCBs cannot be represented graphically.

The three Adaptive Management processes described above will result in management approaches that are tailored to case-specific considerations, including the chemical nature of the COC, the relative magnitude of detected concentrations, the physical area of the exceedance, the potential for exposure to site receptors, and any seasonal or tidal effects noted in the data set.

6.4 RCRA Alternative Evaluation Standards

RCRA alternative evaluation standards (RCRA Standards) reflect the major technical components of corrective measure alternatives including cleanup of releases, source control, and management of wastes (USEPA 1994b). The corrective measure alternatives for RAs 1 through RA 9 identified in Sections 6.6 through 6.14 are evaluated based on compliance with the following four RCRA Standards and Other Factors:

1. Protect human health and the environment
2. Attain FMCLs
3. Control the source of releases to reduce or eliminate, to the extent practicable, further releases that may pose a threat to human health and the environment
4. Comply with any applicable standards for management of wastes (with or without waivers)
5. Other factors
    a. Long-term reliability and effectiveness
    b. Reduction in the toxicity, mobility, or volume of wastes
    c. Short-term effectiveness
    d. Implementability
    e. Cost
    f. Restoration timeframe

The RCRA Standards and Other Factors above are used to evaluate the corrective measure alternatives for RAs 1 through 9. The RCRA Standards and Other Factors (except f.) are based on the definitions outlined in USEPA's RCRA Corrective Action Plan (USEPA 1994b). Other Factor f, restoration timeframe, was added by Boeing. Attachment S6C summarizes all the RCRA Standards and Other Factors used to evaluate the corrective measure alternatives for RAs 1 through 9.

6.5 Evaluation Process

Each of the RA remedial alternatives is evaluated against the RCRA Standards listed in Section 6.4 and defined in Attachment S6C. Each alternative must meet each of the RCRA Standards or it is rejected. Each alternative that passes the RCRA Standard test is evaluated and rated based on the Other Factors listed above. For the evaluation of the Other Factors, the remedial alternative is assigned a rating from 1 (low, minimally meets the factor criteria) to 5 (high, exceeds the factor criteria) for each of the RCRA Other Factors. The assigned ratings for the remedial alternatives that are applicable to each RA are summarized in Tables 6-1C through 6-9C. Explanations and the rationale regarding how the individual ratings presented in the tables were determined for each of the RCRA Alternative Evaluation Standards are presented in Attachment S6C. More detailed descriptions of the proposed elements and scopes of work for remedial alternatives for each RA are presented in Attachment S6C. Detailed cost estimates for alternatives evaluated for RAs are included in Attachment S6D.

The total net benefit row on Tables 6-1C through 6-9C is a calculated sum of the 1-5 numeric ratings for each of the six Other Factors. In general, the greater the total net benefit number the more appropriate the remedial alternative.

Importantly, any strategy resulting from the Adaptive Management process that is determined to be potentially applicable to a particular RA cannot be known or evaluated at this time. Therefore, total net benefit ratings do not consider Adaptive Management.

6.6 RA 1 – 2-10 North Sheetpile - Area

RA 1 contains the 2-10 North Sheetpile and surrounding area. It is located in the paved industrial area within the footprint of the 2-10 Building (Figure 6-3A). A small portion of the RA extends into the unpaved shoreline area below the 2-10 Building overhang. The 2-10 Building is an active building with Boeing personnel present up to 24 hours per day. The original source of contamination at RA 1 is believed to have been the TCE degreaser associated with RCRA Unit AOC 2-10.3A. The degreaser was decommissioned in the late 1990s and the area with the highest concentrations of COCs in soil and groundwater were surrounded by a steel sheetpile containment structure to block cVOC (TCE, cDCE, and VC) migration to the waterway.

RA 1 has been subjected to several IMs as described in Sections 3.5 and 4.3 and Attachment S3C, including the ongoing IM designed to further remove cVOCs from vadose soil and groundwater. Currently groundwater samples are obtained quarterly from wells that are completed inside and outside of the 2-10 North Sheetpile to track the progress of the ongoing IM. Groundwater originating from RA 1 does not contaminate the soil in RA 7.

RA 1 contains groundwater with concentrations of cVOCs, arsenic, and copper that are greater than their respective FMCLs. The respective exceedance areas for these constituents are identified in Table 6-1A and presented in the various figures identified below. Pending COC BEHP was also identified in this RA at concentrations worthy of further evaluation under short-term groundwater monitoring process outlined in Section 6.3.5.

Areas of impacted groundwater in Plant 2 have undergone a variety of IMs, generally designed to contain or reduce contaminant mass within the impacted area. IMs are not specifically designed to achieve regulatory cleanup levels such as the TMCLs or FMCLs for Plant 2; however, some of the technologies used to perform the groundwater IMs are capable of effectively achieving TMCLs and FMCLs.

Table 3-2 presents the groundwater IMs that have been performed or are currently being performed at Plant 2 and lists the associated documents. Detailed descriptions of the groundwater IMs and associated

RA 1 – 2-10 North Sheetpile Area

Key Features

2-10 North Sheetpile Area is located inside the active 2-10 Building.

The area has been subject of previous IMs based on sheetpile containment and ERD/SVE technologies.

COCs Driving Remedy Selection

Groundwater: cVOCs (TCE, cDCE, and VC)

Considerations Affecting Remedy Selection: TCE present in soil above the leaching SL and FMCLs, are a potential source to groundwater in this RA. Ongoing IM actions targeting cVOCs are effectively reducing both soil and groundwater concentrations.

Ongoing groundwater monitoring using existing monitoring well network is used to evaluate IM effectiveness.

Diffusion from decommissioned TCE degreaser may be an ongoing, but slow source of TCE.

Arsenic and copper in groundwater are suspected to be comprised of false positive results on the basis of data collection or analysis methods.

RCRA Units Associated with Current RA Corrective Action(s)

AOC-2-10.3A

POC Monitoring Wells

PL2-213A, PL2-214A

documents are included in Attachment S3C and referenced in Section 8.4. General locations of these IMs are shown in Figure 3-5.

Exceedance Area	Associated Figures
cVOC-15 and cVOC-16	Figures 4-2E and 6-3A
Arsenic-9 and Arsenic-12	Figures 4-4E and 6-3A
CuZn-16	Figures 4-5E and 6-3A

Exceedance areas Arsenic-9, Arsenic-12, and CuZn-16 are based almost exclusively on probe data. BEHP (pending COC) was detected in a sample from well PL2-258A in 2008 but this is likely an anomalous result. Metals and BEHP data from POC wells will be evaluated to determine if the Adaptive Management processes for inorganics or organics (Figures 6-12 and 6-13, respectively) are warranted.

TCE is the only constituent detected in RA 1 soil samples (total of three samples) at concentrations greater than its FMCL (Table 6-1A and Figure 6-3A). These concentrations predate an active IM specifically designed to reduce these soil concentrations. New post-IM concentrations will be available after the IM is complete and before design of the corrective measure. Concentrations of TCE, cDCE, VC, cadmium, and PCBs exceeding the leaching SLs were identified in nine soil sample locations down to 10 feet bgs (exceedance locations and concentrations are presented in Figure 6-3A). PCBs concentrations are below the soil FMCL and have never been detected in groundwater samples from push probes or wells in this RA; therefore, PCBs are not considered a COC for this RA.

Figure 6-3B presents the proposed remedial alternative for RA 1 to support the discussion in the sections that follow. Conceptual site model (CSM) cross sections for RA 1 are presented in Figures 6-3C and 6-3D. The east-west cross section alignment for both figures is shown on Figure 6-3A. Figure 6-3C depicts the RA 1 CSM based on data through January 2013. Figure 6-3D depicts the RA 1 CSM adjusted with data through December 2016, where applicable.

6.6.1 Applicable Remedial Technologies for RA 1

Remedial alternatives for RA 1 will address the cVOCs and metals results that exceed soil and/or groundwater FMCLs. Constituents detected in soil or groundwater at concentrations greater than their applicable FMCLs in RA 1 are presented in Table 6-1A and Figure 6-3A. Table 6-1A identifies the technologies that were considered to address the COCs present in RA 1. Applicable technologies are described in the text that follows:

- **Engineering Controls**. Existing 2-10 Building concrete floor slab serves as a physical barrier to direct contact with soil that exceeds the industrial FMCLs. Approximately 20 feet of RA 1 along the shoreline lies beneath the 2-10 Building overhang, but is not physically accessible to site workers or the public because of the configuration of the building. Additionally, a steel sheetpile containment structure was installed as part of IMs conducted within this RA. These structures must remain in place and operational until soil and groundwater results are in compliance with the FMCLs.

- **Institutional Controls**. Institutional controls in the form of an environmental covenant would require the area to be covered by pavement or building(s). Additional actions (e.g., excavation of the TCE degreaser, sampling of concrete) would be required in the event that either (a) the building undergoes major renovation or is demolished, or (b) shoreline monitoring well results indicate that FMCL exceedances of cVOCs in groundwater are present at the POC. These actions would be completed consistent with conditions and technologies described in Section 6.3.

- **Long-Term Groundwater Monitoring**. Shoreline monitoring wells PL2-258A and PL2-258B are installed at the POC downgradient of RA 1. Monitoring at these locations will continue on a semiannual schedule as part of the shoreline monitoring program described in Attachment S6A. Shoreline well PL2-258C is not proposed for continued shoreline monitoring based on historical data demonstrating consistent compliance with FMCLs.

- **Short-Term Groundwater Monitoring.** Shoreline well PL2-258A will be analyzed for BEHP for four semiannual shoreline monitoring events (Table 2-1 and Attachment S2B). If there are no FMCL exceedances for BEHP the data will be evaluated without the use of statistics and Boeing will discontinue monitoring for BEHP. If there are FMCL exceedances PL2-258A will be monitored for BEHP for a total of eight events and those data will be evaluated using the 95% UCL statistical method to determine if continued BEHP monitoring is warranted. Boeing and USEPA will review the data and statistical evaluation to determine the appropriate course of action for continued monitoring and/or Adaptive Management following the process presented in Figure 6-13 for BEHP.

  DGI probe data for inorganics in RA 1 are likely to be false positive analytical results. Boeing and USEPA will review the inorganics data from POC wells in RA 1 to determine the appropriate course of action using the Adaptive Management process for inorganics presented in Figure 6-12.

- **ERD**. ERD is already being performed successfully in this RA for remediation of cVOC-15 and cVOC-16. Boeing proposes to continue ERD in RA 1, but would enhance ERD by the addition of appropriate anaerobic bacterial species near PL2-218A and PL2-218B where, due to the low remaining concentrations of cVOCs, the microbial counts might decline to levels below optimum for continued degradation. Based on the prior success of ERD at the site, Boeing anticipates that continued performance of ERD in the 2-10 Sheetpile would attain cVOC concentrations that are in compliance with groundwater FMCLs at RA 1.

- **Excavation with Off-Site Disposa**l. Excavation of TCE-impacted soil within RA 1 might be performed to meet the industrial soil FMCLs and leaching SLs for TCE that are potentially impacting cVOC-15 and cVOC-16. This technology would be considered if TCE concentrations in groundwater cannot achieve compliance with FMCLs despite the completion of IMs, or if compliance cannot be achieved by continued implementation of ERD. The depth of any excavation would be determined at the time the work is completed based on soil sampling results and/or confirmation sampling. The excavation depth is anticipated to range from 5 to 11 feet bgs, resulting in the removal of approximately 310 cy of soil.

  Additionally, excavation in this area may require removal and off-site disposal of the decommissioned concrete features including the building slab and concrete TCE degreaser structure. Concrete will be disposed of in accordance with Boeing's standard

waste handling characterization and disposal procedures. The concrete structure is suspected to contain residual TCE that may represent an ongoing source of contamination. The need for any concrete removal actions would be evaluated when and if redevelopment, remodeling, or other significant work is performed on the building.

In addition to the remedial technologies applicable to cVOCs, Adaptive Management processes are reserved to address the potential need for groundwater corrective measures for inorganics and organics:

- **Adaptive Management for Inorganics in Groundwater**. The potential for groundwater treatment technology has been retained for the inorganic constituents represented by exceedance areas Arsenic-9, Arsenic-12, and CuZn-16. These exceedance areas are well-delineated and, in some cases, appear stable or decreasing. Although the data for each area vary, the inorganic constituents have generally not been detected at concentrations greater than FMCLs downgradient at the POC, except infrequent FMCL exceedances for arsenic in PL2-258A. Ongoing groundwater monitoring data considered through the Adaptive Management process will indicate if any specific corrective action for one or more of these exceedance areas is warranted.

  Where Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations. The Adaptive Management process for inorganic COCs is shown graphically on Figure 6-12.

- **Adaptive Management for Organics in Groundwater.** The potential for groundwater treatment technology has been retained for the organic constituents represented by exceedance areas cVOC-15 and cVOC-16. These exceedance areas are generally well delineated, and only VC has commonly been detected at concentrations greater than FMCLs at the POC monitoring wells PL2-258A and PL2-258B.

  Implementation of the proposed corrective measures is expected to achieve FMCLs for these exceedance areas; however, there might be some POC locations that do not achieve or consistently maintain FMCLs over time for organic COCs. A suitable corrective action technology will only be considered if groundwater monitoring data indicate that further consideration of corrective actions for one or more of these exceedance areas is warranted.

  Where Adaptive Management for organics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective technology determinations. The Adaptive Management process for organic COCs is shown graphically on Figure 6-13.

6.6.2 Remedial Alternatives for RA 1

Applicable remedial technologies for soil and groundwater in RA 1 have been assembled into remedial alternatives that are based on media, constituent, and location-specific considerations. In addition to impacted groundwater, the remedial alternatives consider the presence of TCE in remnant subsurface degreaser concrete and in soil at concentrations greater than the proposed industrial soil FMCL and leaching SLs. Assembled groups of remedial technologies are identified below as numbered alternatives and are summarized in Table 6-1B.

Alternative 1 – Corrective Action Not Required with Controls: This remedial alternative is applicable for areas with no active measures, but where the following remedial technologies are used:

- No Corrective Action
- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics and BEHP

Alternative 1 requires no additional active corrective actions for soil, as long as the building remains in place and indefinitely if post-IM- testing indicates that TCE in soil is no longer a source to groundwater. However, Alternative 1 would utilize remedial technologies that are currently in place, which includes Engineering Controls and Institutional Controls. This alternative depends on the success of the bio/chemical degradation processes, which have been enhanced by the current IM to remediate the organic constituents present in RA 1 to eventually achieve compliance with FMCLs. The protectiveness of this alternative would be evaluated with short- and long-term groundwater monitoring in the shoreline monitoring wells. This alternative serves as the baseline for comparison to other alternatives.

Alternative 2 – ERD: This remedial alternative adds ERD to Alternative 1 and would be expected to decrease the restoration timeframe relative to Alternative 1. Alternative 2 includes the following remedial technologies:

- ERD
- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics and BEHP

In addition to long- and short-term groundwater monitoring performed in the shoreline monitoring wells within RA 1, this alternative would likely require additional monitoring in existing and/or new wells to evaluate the performance of the ERD remedial technology.

Alternative 2a – ERD and Excavation with Off-Site Disposal: This remedial alternative adds excavation of soil hot spots and potential decommissioning of the TCE degreaser structure to Alternative 2. The following remedial technologies are applicable to the alternative:

- ERD
- Excavation with Off-Site Disposal
- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs

- Short-term Monitoring for inorganics and BEHP

The excavation activities would be expected to decrease the restoration timeframe relative to Alternatives 1 and 2. Because of the ongoing manufacturing and testing activity in the 2-10 Building, the excavation with disposal add-on could not be implemented in a timely manner, but would be available at some future time if the building is vacated. As with Alternative 2, this alternative would likely require additional monitoring in existing and/or new wells to evaluate the performance of the ERD remedial technology; and additional soil and concrete testing prior to excavation and disposal.

Alternative AM-1 – Adaptive Management for Inorganics in Groundwater: The Adaptive Management process for inorganics might be combined with any of the previously described alternatives as noted in Table 6-1A. Adaptive Management would be considered if future shoreline monitoring data indicate that inorganic COCs are present at concentrations exceeding FMCLs in groundwater at the POC as described in Section 6.3.8 and Figure 6-12. Where Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations.

Alternative AM-2 – Adaptive Management for Organics in Groundwater: The Adaptive Management process for organics might be combined with any of the previously described alternatives as noted in Table 6-1A. Adaptive Management would be considered if future shoreline monitoring data indicate that organic COCs are present at concentrations exceeding FMCLs in groundwater at the POC as described in Section 6.3.8 and Figure 6-13. Where Adaptive Management for organics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations.

6.6.3 RA 1 – Remedial Alternative Descriptions and Total Net Benefit Ratings

In accordance with the evaluation process described in Section 6.5, Table 6-1C presents a summary of how effectively the proposed remedial alternatives meet the RCRA criteria. The following summarizes the RA 1 remedial alternatives and provides the net benefit score from Table 6-1C. Evaluation of RA 1 remedial alternatives is provided in detail in Attachment S6C, which includes complete descriptions of the proposed elements and scopes of work for the remedial alternatives.

Alternative 1: Corrective Action Not Required with Controls – Alternative 1 is based on establishing an environmental covenant for the site and utilizing existing engineering controls including security fencing, pavement, and stormwater management to control exposure pathways to the environment. Two additional controls are specific to RA 1: the concrete floor slab inside of a building covers contaminated soil and groundwater; and a steel sheetpile structure driven to approximately 25 to 30 feet bgs contains the most contaminated soil and groundwater in RA 1 and prevents contaminant transport by groundwater to the POC. Alternative 1 also includes short-term and long-term groundwater monitoring at the POC (i.e., shoreline monitoring). The total net benefit rating for Alternative 1 is 21, as noted in Table 6-1C.

Alternative 2: ERD – Alternative 2, ERD, includes the injection of nutrients into groundwater via existing injection wells to enhance reducing geochemical conditions and increase the rate of biological degradation and destruction of cVOCs in RA 1. RA 1 is currently being remediated

under interim corrective actions using ERD as the one of the remedial technologies. As a result, the exceedance areas for cVOCs are well delineated and do not require a pre-design sampling event to establish its current nature and extent. In addition, injection and monitoring well networks necessary to perform ERD are already installed at RA 1 as shown in Figure 6-3B.

ERD has been implemented as an IM in RA 1 and ongoing monitoring data have demonstrated the effectiveness of this remedial alternative. Figures 6-3C and 6-3D present an east-west CSM cross section through RA 1 along the alignment shown in Figure 6-3B. Figure 6-3C presents the CSM of RA 1 showing probe and well locations, screened intervals, and pre-IM cVOC concentrations and exceedance areas. Figure 6-3D presents the same CSM cross section with existing RA 1 IM injection and monitoring wells added and cVOC data adjusted through December 2016 where applicable. Comparison of the size and concentrations of the cVOC exceedance areas presented in both figures demonstrates that ERD is an effective remedial alternative for the site-specific conditions at RA 1. Figure 6-3D shows that the concrete-filled former degreaser sump inside of the sheetpile continues to diffuse cVOCs into groundwater; however, groundwater impacts remain localized to a small area around that source.

This alternative would include approximately annual nutrient substrate injection events, semiannual groundwater sampling in up to 13 existing monitoring wells (two of which are in the shoreline monitoring well network) and semiannual reporting. Injection, monitoring, and reporting under this alternative are assumed to take place for 5 years. The total net benefit rating for Alternative 2 is 25, as noted in Table 6-1C.

Alternative 2a: ERD and Excavation with Off-Site Disposal – The ERD portion of this alternative is the same as Alternative 2 above. Alternative 2a includes the additional scope of work associated with excavation and off-site disposal of vadose-zone soil with the greatest concentrations of cVOC constituents based on DGI data. The volume of soil that would be excavated in RA 1 is estimated to be 310 cy. Disposal costs for the excavated soil are based on an assumed “contained-in” designation (CID) by Ecology. The CID, if granted by Ecology, would allow the excavated soil to be disposed at a Subtitle D landfill. The total net benefit rating for Alternative 2a is 22, as noted in Table 6-1C.

Alternative AM-1: Adaptive Management for Inorganics in Groundwater – If the Adaptive Management process for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations as shown in Figure 6-12. The appropriate strategy resulting from this process cannot be known or evaluated at this time.

Alternative AM-2: Adaptive Management for Organics in Groundwater – If the Adaptive Management process for organics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations as shown in Figure 6-13. The appropriate strategy resulting from this process cannot be known or evaluated at this time.

6.6.4 RA 1 – Recommended Remedial Alternative

As noted in Table 6-1C, the remedial alternative with the greatest total net benefit is Alternative 2 (ERD) with a result of 25 out of a possible 30. Previous implementation of ERD IMs at Plant 2, including at RA 1, have demonstrated that this technology is effective and the use of an existing infrastructure for ongoing ERD IMs at RA 1 make Alternative 2 highly implementable.

Comparatively, the estimated cost for implementation of Alternative 2 is not prohibitive, and the destruction of the cVOCs provides substantial benefit. Therefore, Alternative 2, ERD is the recommended remedial alternative for RA 1. The existing layout for the injection well network in RA 1 is presented in Figure 6-3B.

Alternative 2 is designed to remediate the cVOC groundwater exceedance areas present in RA 1 but it does not directly remediate the possible arsenic and copper exceedance areas. Successful completion of Alternative 2 is expected to allow groundwater to return to natural geochemical conditions, which should reduce metals concentrations within approximately 5 years. If future shoreline monitoring data indicate inorganic or organic FMCL exceedances in groundwater, then Alternatives AM-1 or AM-2, respectively, would be pursued in coordination with EPA.

Supporting technical discussions and rationale for the rating assigned to each of the RCRA Alternative Evaluation Standards are presented in Attachment S6C.

6.7 RA 2 – 2-10 South Sheetpile Area

RA 2 is very similar to RA 1 with respect to the physical structures, RCRA history, nature of release, and IMs conducted to date. RA 2 contains the 2-10 South Sheetpile and surrounding area. It is in the paved industrial area within the footprint of the 2-10 Building (Figure 6-4A). A small portion of the RA extends into the unpaved shoreline area below the 2-10 Building overhang. The 2-10 Building, which overlies RA 2, is an active building with staff present up to 24 hours per day. The original source of contamination at RA 2 is believed to have been the TCE degreaser associated with RCRA Unit AOC 2-10.4A. The degreaser was decommissioned in the 1990s and the area with the highest soil and groundwater concentrations were surrounded by a steel sheetpile containment structure to block cVOC (TCE and VC) migration to the waterway.

RA 2 has been subjected to several IMs as described in Sections 3.5 and 4.3 and Attachment S3C, including the ongoing IM designed to further remove cVOCs from vadose soil and groundwater. Currently groundwater samples are obtained quarterly from wells that are completed inside and outside of the 2-10 South Sheetpile to track the progress of the ongoing IM. Groundwater originating from RA 2 does not contaminate the soil in RA 7.

RA 2 contains groundwater with concentrations of cVOCs, arsenic, and copper that are greater than their respective FMCLs. The respective exceedance areas for these constituents are identified in Table 6-2A and presented in the various figures identified below.

Exceedance Area	Associated Figures
cVOC-13 and cVOC-14	Figures 4-2E and 6-4A
Arsenic-6	Figures 4-4E and 6-4A
CuZn-14 and CuZn-15	Figures 4-5E and 6-4A

RA 2 – 2-10 South Sheetpile Area

Key Features

2-10 South Sheetpile Area is located inside the active 2-10 Building.

The area has been subject of previous IMs based on sheetpile containment, and ERD/SVE technologies.

COCs Driving Remedy Selection

Groundwater: cVOCs (TCE and VC)

Considerations Affecting Remedy Selection:

TCE present in soil above the leaching SL and FMCLs, are a potential source to groundwater in this RA. Ongoing IM actions targeting cVOCs are effectively reducing both soil and groundwater concentrations.

Ongoing groundwater monitoring using existing monitoring well network is used to evaluate IM effectiveness. Metal groundwater exceedance areas are suspected to be comprised of false positive results on the basis of data collection or analysis methods.

RCRA Units Associated with Current RA Corrective Action(s)

AOC-2-10.4A

POC Monitoring Wells

PL2-213A, PL2-214A, PL2-214B

Exceedance areas Arsenic-6, CuZn-14, and CuZn-15 are based almost exclusively on probe data. Data from POC wells will be evaluated to determine if the Adaptive Management process for inorganics (Figure 6-12) is warranted.

TCE is the only constituent detected in RA 2 soil samples at concentrations greater than the FMCLs (Table 6-2A and Figure 6-4A). One soil sample location (PL2-209A) in the 2-10 South Sheetpile exceeds the FMCL for TCE. This concentration predates an active IM specifically designed to reduce these soil concentrations. New post-IM concentrations will be available after the IM is complete and before design of the corrective measure. Pre-IM concentrations of TCE and VC exceeding the leaching SLs were identified in eight soil sample locations at depths between 8 and 10 feet bgs (exceedance locations and concentrations are presented in Figure 6-4A).

Figure 6-4B presents the proposed remedial alternative for RA 2 to support the discussion in the sections that follow. CSM cross sections for RA 2 are presented in Figures 6-4C and 6-4D. The east-west cross section alignment for both figures is shown on Figure 6-4B. Figure 6-4C depicts the RA 2 CSM based on data through January 2013. Figure 6-4D depicts the RA 2 CSM adjusted with data through December 2016, where applicable.

6.7.1 Applicable Remedial Technologies for RA 2

Remedial alternatives for RA 2 will address the cVOCs and metals results that exceed soil and/or groundwater FMCLs. Constituents detected in soil or groundwater at concentrations greater than their applicable FMCLs in RA 2 are presented in Table 6-2A and Figure 6-4A. Table 6-2A identifies the technologies that were considered to address the COCs present in RA 2. Applicable technologies are described in the text that follows:

- **Engineering Controls**. The existing 2-10 Building concrete floor slab serves as a physical barrier to direct contact with soil that exceeds the industrial FMCLs. Approximately 20 feet of RA 2 along the shoreline lies beneath the 2-10 Building overhang, but is not physically accessible to site workers or the public because of the configuration of the building. Additionally, a steel sheetpile containment structure was installed as part of IMs conducted within this RA. This structure must remain in place and operational until soil and groundwater results are in compliance with the FMCLs.
- **Institutional Controls**. Institutional controls in the form of an environmental covenant would require the area be covered with pavement or building(s). If post-IM remedial design sampling indicates that TCE contamination remains, additional action (e.g., excavation of the TCE degreaser, sampling of concrete) would be required in the event that either the building undergoes major renovation or is demolished, or shoreline monitoring well results indicate that exceedances of cVOCs in groundwater are present at the POC. These actions would be completed consistent with conditions and technologies described in Section 6.3.
- **Long-Term Groundwater Monitoring**. Existing shoreline monitoring wells PL2-213A, PL2-214A, and PL2-214B are installed at the POC downgradient of RA 2 and will continue to be monitored on a semiannual schedule as part of the shoreline monitoring program as described in Attachment S6A. Shoreline well PL2-214C is not proposed for continued shoreline monitoring based on historical data demonstrating consistent compliance with FMCLs.

- **Short-Term Groundwater Monitoring**. DGI probe data for inorganics in RA 2 are likely to be false positive analytical results. Boeing proposes to sample groundwater from the shoreline monitoring well network downgradient of RA 2, specifically wells PL2-213A, PL2-214A, and PL2-214B for arsenic and nickel and evaluate those results. Boeing and USEPA will review the inorganics data from POC wells in RA 2 to determine the appropriate course of action using the Adaptive Management process for inorganics presented in Figure 6-12.
- **ERD**. ERD is already being performed successfully in this RA for remediation of cVOC-13 and cVOC-14. Due to the low remaining concentrations of cVOCs, the microbial counts are less than optimum for continued degradation. Therefore, Boeing proposes to continue ERD in RA 2, but might enhance ERD by adding appropriate dehalococcoides microbial species to the aquifer in the vicinity of PL2-257A, located outside the east sheetpile wall. Based on the prior success of ERD at the site, Boeing anticipates that continued performance of ERD in the 2-10 Sheetpile would attain cVOC concentrations that are in compliance with groundwater FMCLs at RA 2.
- **Excavation with Off-Site Disposal**. Excavation of TCE-impacted soil within RA 2 may be performed to meet the industrial soil FMCLs and leaching SLs for TCE that are potentially impacting cVOC-13 and cVOC-14. This technology would be considered if TCE is not already in compliance as a result of IM's or if compliance cannot be achieved by ERD. The depth of the excavation would be determined at the time the work is completed based on soil sampling results and/or confirmation sampling. The excavation depth is anticipated to range from 8 to 11 feet bgs, resulting in the removal of approximately 360 cy of soil.

  Additionally, excavation in this area may require removal and off-site disposal of the decommissioned concrete features including the building slab. The need for any concrete removal actions would be evaluated when and if redevelopment, remodeling, or other significant work is performed on the building.

In addition to the remedial technologies applicable to cVOCs, Adaptive Management process are retained to address the potential need for groundwater corrective measures for inorganics and organics:

- **Adaptive Management for Inorganics in Groundwater**. The potential for groundwater treatment technology has been retained for the inorganic constituents represented by exceedance areas Arsenic-6, CuZn-14, and CuZn-15. These exceedance areas are well-delineated and, in some cases, appear stable or decreasing. Although the data for each area vary, these inorganic constituents have not been detected at concentrations greater than FMCLs downgradient at the POC, except a single exceedance of the pending COC nickel in the August 2011 sample from PL2-214B at a concentration of 9.0 µg/L (FMCL is 8.0 µg/L). Ongoing groundwater monitoring data considered through the Adaptive Management process will indicate if any specific corrective action for one or more of these exceedance areas is warranted.

  Where Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations. The Adaptive Management process for inorganic COCs is shown graphically on Figure 6-12.

- **Adaptive Management for Organics in Groundwater.** The potential for groundwater treatment technology has been retained for the organic constituents represented by exceedance areas cVOC-13 and cVOC-14. These exceedance areas are generally well delineated and cVOCs have not been detected in samples from POC monitoring wells PL2-213A, PL2-214A, and PL2-214B.

  Implementation of the proposed corrective measures is expected to achieve FMCLs for these exceedance areas; however, there might be some POC locations that do not achieve or consistently maintain FMCLs over time for organic COCs. A suitable corrective action technology will only be considered if groundwater monitoring data indicate that further consideration of corrective action for one or more of these exceedance areas is warranted.

  Where Adaptive Management for organics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective technology determinations. The Adaptive Management process for organic COCs is shown graphically on Figure 6-13.

6.7.2 Remedial Alternatives for RA 2

Applicable remedial technologies for soil and groundwater in RA 2 have been assembled into remedial alternatives that are based on media, constituent, and location-specific considerations. In addition to impacted groundwater, the remedial alternatives consider the presence of TCE in the 2-10 Building remnant subsurface degreaser concrete and in soil at concentrations greater than the proposed industrial soil FMCL and leaching SLs. Assembled groups of remedial technologies are identified below as numbered alternatives and are summarized in Table 6-2B.

Alternative 1 – Corrective Action Not Required with Controls: This remedial alternative is applicable for areas with no active measures, but where the following remedial technologies are used:

- No Corrective Action
- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics

Alternative 1 requires no additional active corrective actions for soil, as long as the building remains in place and indefinitely if post-IM testing indicates that TCE in soil is no longer a source to groundwater. However, Alternative 1 would utilize remedial technologies that are currently in place, which includes Engineering Controls and Institutional Controls. This alternative depends on the success of the bio/chemical degradation processes, which have been enhanced by the current IM to remediate the organic constituents present in RA 2 to eventually achieve compliance with FMCLs. The protectiveness of this alternative would be evaluated with short- and long-term groundwater monitoring in the shoreline monitoring wells. This alternative serves as the baseline for comparison to other alternatives.

Alternative 2 – ERD: This remedial alternative adds ERD to Alternative 1 and would be expected to decrease the restoration timeframe relative to Alternative 1. Alternative 2 includes the following remedial technologies:

- ERD
- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics

In addition to long- and short-term groundwater monitoring performed in the shoreline monitoring wells within RA 2, this alternative would likely require additional monitoring in existing and/or new wells to evaluate the performance of the ERD remedial technology.

Alternative 2a – ERD and Excavation with Off-Site Disposal: This remedial alternative adds excavation of soil hot spots and/or the decommissioned TCE degreaser structure to Alternative 2, and includes the following remedial technologies:

- ERD
- Excavation with Off-Site Disposal
- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics

The excavation activities would be expected to decrease the restoration timeframe relative to Alternative 1 and 2. Because of the activity in the 2-10 Building, the excavation with disposal add-on could not be implemented in a timely manner, but would be available at some future time if the building is vacated. As with Alternative 2, this alternative would likely require additional monitoring in existing and/or new wells to evaluate the performance of the ERD remedial technology; and additional soil and concrete testing prior to excavation and disposal.

Alternative AM-1 – Adaptive Management for Inorganics in Groundwater: The Adaptive Management process for inorganics might be combined with any of the previously described alternatives as noted in Table 6-2A. Adaptive Management would be considered if future shoreline monitoring data indicate that inorganic COCs are present at concentrations exceeding FMCLs in groundwater at the POC as described in Section 6.3.8 and Figure 6-12. Where Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations.

Alternative AM-2 – Adaptive Management for Organics in Groundwater: The Adaptive Management process for organics might be combined with any of the previously described alternatives as noted in Table 6-2A. Adaptive Management would be considered if future shoreline monitoring data indicate that organic COCs are present at concentrations exceeding

FMCLs in groundwater at the POC as described in Section 6.3.8 and Figure 6-13. Where Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations.

6.7.3 RA 2 – Remedial Alternative Descriptions and Total Net Benefit Ratings

A summary table rating how effectively the proposed remedial alternatives meet RCRA Alternative Evaluation Standards and other factors is presented as Table 6-2C. Descriptions of the proposed elements and scopes of work for the RA 2 remedial alternatives are presented in Attachment S6C.

Alternative 1: Corrective Action Not Required with Controls – Alternative 1 is based on establishing an environmental covenant for the site and utilizing existing engineering controls including security fencing, pavement, and stormwater management to control exposure pathways to the environment. Two additional controls are specific to RA 2: the concrete floor slab inside of a building covers contaminated soil and groundwater; and a steel sheetpile structure driven to approximately 25 to 30 feet bgs, which contains the most contaminated soil and groundwater in RA 2 and prevents contaminant transport by groundwater to the POC. Alternative 1 also includes short-term and long-term groundwater monitoring at the POC (i.e., shoreline monitoring). The total net benefit rating for Alternative 1 is 21, as noted in Table 6-2C.

Alternative 2: ERD – Alternative 2 is similar to Alternative 1, but adds the injection of nutrients into groundwater via existing injection wells to enhance reducing geochemical conditions and increase the rate of biological degradation and destruction of cVOCs in RA 2. RA 2 is currently being remediated under interim corrective actions using ERD as the one of the remedial technologies. As a result, the exceedance areas for cVOCs are well delineated and do not require a pre-design sampling event to establish its current nature and extent. In addition, injection and monitoring well networks necessary to perform ERD are already installed at RA 2 as shown in Figure 6-4B.

ERD has been implemented as an IM in RA 2 and ongoing monitoring data have demonstrated the effectiveness of this remedial alternative. Figures 6-4C and 6-4D present an east-west CSM cross section through RA 2 along the alignment shown in Figure 6-4B. Figure 6-4C presents the CSM of RA 2 showing probe and well locations, screened intervals, and pre-IM cVOC concentrations and exceedance areas. Figure 6-4D presents the same CSM cross section with existing RA 2 IM injection and monitoring wells added and cVOC data adjusted through December 2016 where applicable. Comparison of the size and concentrations of the cVOC exceedance areas presented in both figures demonstrates that ERD is an effective remedial alternative for the site-specific conditions at RA 2. Figure 6-4D shows that only a small area of groundwater with cVOC concentrations exceeding FMCLs exists immediately inside and outside of the east (upgradient) sheetpile wall.

This alternative would include approximately annual nutrient substrate injection events, semiannual groundwater sampling in up to 12 existing ERD monitoring wells, and semiannual reporting. Injection, monitoring, and reporting under this alternative are assumed to take place for 5 years. The total net benefit rating for Alternative 2 is 25, as noted in Table 6-2C.

Alternative 2a: ERD and Excavation with Off-Site Disposal – The ERD portion of this alternative is the same as Alternative 2 above. Alternative 2a modifies Alternative 2 by adding excavation with off-site disposal of vadose-zone soil with the greatest concentrations of cVOC

constituents. The volume of soil that would be excavated in RA 2 is estimated to be 360 cy. Disposal costs for the excavated soil are based on an assumed CID. The total net benefit rating for Alternative 2a is 22, as noted in Table 6-2C.

Alternative AM-1: Adaptive Management for Inorganics in Groundwater – If the Adaptive Management process for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations as shown in Figure 6-12. The appropriate strategy resulting from this process cannot be known or evaluated at this time.

Alternative AM-2: Adaptive Management for Organics in Groundwater – If the Adaptive Management process for organics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations as shown in Figure 6-13. The appropriate strategy resulting from this process cannot be known or evaluated at this time.

6.7.4 RA 2 – Recommended Remedial Alternative

As noted in Table 6-2C, the remedial alternative with the greatest total net benefit is Alternative 2, ERD with a result of 25 out of a possible 30. Previous implementation of ERD IMs at Plant 2, including at RA 2, have demonstrated that this technology is effective. The use of an existing infrastructure for ongoing ERD IMs at RA 2 make Alternative 2 highly implementable. Comparatively, the estimated cost for implementation of Alternative 2 is not prohibitive and the destruction of the cVOCs provides substantial benefit. Therefore, Alternative 2, ERD is the recommended remedial alternative for RA 2. The existing layout for the injection well network in RA 2 is presented in Figure 6-4B.

Alternative 2 is designed to remediate the cVOC groundwater exceedance areas present in RA 2 but it does not directly remediate the possible arsenic, and copper exceedance areas in RA 2. Successful completion of Alternative 2 is expected to allow groundwater to return to natural geochemical conditions, which should reduce metals concentrations in approximately 5 years. If future shoreline monitoring data indicate inorganic or organic FMCL exceedances in groundwater, then Alternatives AM-1 or AM-2, respectively, would be pursued in coordination with EPA.

Supporting technical discussions and rationale for the rating assigned to each of the RCRA Alternative Evaluation Standards are presented in Attachment S6C.

6.8 RA 3 – 2-31 Area

RA 3 consists of both paved industrial area and unpaved shoreline area west of the 2-31 Building and south of the 16th Avenue South Bridge. RA 3 occupies an area previously covered by a portion of the 2-31 Building that was demolished as part of the Plant 2 2010-2012 demolition and redevelopment, and RA 3 extends into the Plant 2 unpaved shoreline area where stormwater management controls are present. Portions of RA 3 contain crush concrete backfill associated with the Plant 2 2010-2012 demolition and redevelopment. There are currently no buildings covering RA 3. The portion of RA 3 within the paved industrial area is covered by asphalt pavement.

Five different RCRA units are associated with this RA as identified in the adjacent text box. Exceedance areas cVOC-10 and cVOC-11 are associated with the RCRA Unit 2-31 TCE Degreaser (AOC 2-31.21), which is located within the footprint of the un-demolished portion of the 2-31 Building and historical TCE piping removed in 2011.

RA 3 was largely included in the 2010-2012 Plant 2 demolition and redevelopment and was subject to the IM described in Sections 3.1 and 4.1 and Attachment S3A. Groundwater impacts within the footprint of the soil excavation at RA 3 were treated by mixing the proprietary remediation compound, 3D Microemulsion™ (3DMe), in the groundwater surface in the excavation prior to backfilling to stimulate the aquifer to become more geochemically reducing and initiate ERD. The IM (excavation and initiation of ERD) was performed after the DGI for the 2-31 Area, which was performed in 2009. As a result, soil and groundwater conditions in RA 3 are likely improved from those presented in the 2-31 Area DGI.

RA 3 consists of groundwater with COC concentrations exceeding the FMCLs for cVOCs, arsenic and zinc. In addition, PCBs have been intermittently detected in groundwater samples at monitoring well PL2-621A.

RA 3 – 2-31 Area

Key Features

Western portion of the 2-31 Area, including areas in the paved and unpaved shoreline areas and the Habitat Area.

COCs Driving Remedy Selection

Groundwater: cVOCs (TCE, cDCE, and VC)

Soil: None

Considerations Affecting Remedy Selection: cVOCs formerly present in soil were removed by excavation to groundwater. ERD was initiated by applying a remediation substrate to the top of the groundwater prior to backfilling the excavation. Detection of PCBs at monitoring well PL2-621A.

Metal groundwater exceedance areas are suspected to be influenced by geochemical conditions or comprised of false positive results on the basis of data collection or analysis methods.

RCRA Units Associated with Current RA Corrective Action(s)

AOC 2-41.32

SWMU 2-31.18

SWMU 2-41.33

SWMU 2-41.34

SWMU 2-41.36

POC Monitoring Wells

PL2-620A, PL2-620B,

PL2-621A, PL2-621B

The respective exceedance areas for these constituents are identified in Table 6-3A and presented in the various figures identified below. Pending COCs BEHP, nickel and cadmium were also identified in this RA at concentrations worthy of further evaluation under the short-term groundwater monitoring process outlined in Section 6.3.5.

Exceedance Area	Associated Figures
cVOC-10 and cVOC-11	Figures 4-2D, 4-2E, and 6-5A
Arsenic-4 and Arsenic-5	Figures 4-4D, 4-4E, and 6-5A
CuZn-10	Figures 4-5D, 4-5E, and 6-5A
Cadmium-3 and Cadmium-4	Figures 4-10D, 4-10E, and 6-5A

CuZn-10 and both arsenic exceedance areas in RA 3 are based almost solely on probe results, which are commonly turbid and potentially result in false positives, especially for constituents, like metals, that tend to adsorb to particulates suspended in turbid probe samples.

There are no soil sample locations with COC concentrations exceeding their FMCLs within RA 3. Concentrations of cDCE, TCE, cadmium, and PCBs exceeding the leaching SLs were identified between 7 and 11 feet bgs (exceedance locations and concentrations are presented in Figure 6-5A).

Figure 6-5B presents the proposed remedial alternative for RA 3 to support the discussion in the sections that follow. A CSM cross section for RA 3 depicting hydrogeologic conditions based on data through January 2013 is presented in Figure 6-5C. The east-west cross section alignment for the RA 3 CSM is shown on Figure 6-5B.

6.8.1 Applicable Remedial Technologies for RA 3

Remedial alternatives for RA 3 were designed to address the presence of cVOCs and specific metals that exceed soil leaching SLs or groundwater FMCLs associated with the 2-31 TCE Degreaser (AOC 2-31.21) and associated TCE piping that impacted soil and groundwater in the 2-31 Area. The constituents or constituent groups that have been detected in groundwater samples at concentrations greater than their applicable FMCLs in RA 3 are presented in Table 6-3A and Figure 6-5A. Table 6-3A identifies the technologies that were considered to address each of the COCs present in RA 3. Applicable technologies are described in the text that follows:

- **Engineering Controls.** Existing pavement in the paved industrial area provides a physical barrier against direct contact with potentially impacted soil by workers and by wildlife. Pavement is also a component of the on-site surface water management system controlling surface water run-on, and eliminating erosion that can expose underlying impacted soil. Essentially all precipitation falling on RA 3 is directed to the site-wide stormwater system as presented in Section 6.3.
- **Institutional Controls.** Institutional controls in the form of an environmental covenant would require approximately three quarters of RA 3 to remain covered by pavement or buildings (the remaining portion of RA 3 is within the unpaved shoreline area). These actions would be completed consistent with conditions and technologies described in Section 6.3.

- **Long-Term Groundwater Monitoring.** Existing shoreline monitoring wells PL2-620A, PL2-620B, PL2-621A, and PL2-621B are installed at the POC downgradient of RA 3 and would continue to be monitored on a semiannual schedule as part of the shoreline monitoring program, as described in Attachment S6A.

- **Short-Term Groundwater Monitoring.** The pending COC nickel was detected at concentrations greater than its FMCL during two of six shoreline monitoring events performed at PL2-621A. Therefore, nickel results from shoreline well PL2-621A, will be evaluated after completing eight shoreline monitoring events using the 95% confidence limit statistical test. Results of this testing will be used to evaluate if DGI nickel data exceedances are caused by saline matrix interference and are not an ongoing FMCL exceedance issue at that location. If nickel concentrations do not statistically exceed the FMCL, monitoring for nickel will be discontinued. If nickel results exceed the FMCL, Boeing will determine the appropriate course of action in consultation with USEPA using the Adaptive Management process for inorganics presented in Figure 6-12.

  Boeing has sampled PL2-620A and PL2-621A for PCBs for four events. PCB data from PL2-620A were consistently non-detect throughout the four events. PCB data from PL2-621A had detections in two of the four PCB sampling events performed at that well. Neither of the detected PCB concentrations was greater than the proposed PQL-based FMCL. The source of PCBs in PL2-621A is not known. However, wells PL2-620A and PL2-621A are downgradient of tunnels backfilled to 1.5 feet above the water table with crushed concrete that contained detectable concentrations of PCBs. PL2-621A will continue to be sampled for PCBs and the data will be evaluated in consultation with USEPA to determine the appropriate course of action to address PCB detections. The Adaptive Management process for PCBs, as described in Section 6.8.3, may be implemented in this RA.

  Shoreline wells PL2-620A and PL2-621A will be analyzed for BEHP for four semiannual shoreline monitoring events. If there are no FMCL exceedances for BEHP the data will be evaluated without the use of statistics. If there are FMCL exceedances those wells will be monitored for BEHP for a total of eight events and those data will be evaluated using the 95% UCL statistical method to determine if continued BEHP monitoring is warranted. Boeing and USEPA will review the data and statistical evaluation to determine the appropriate course of action for continued monitoring and/or Adaptive Management following the process presented in Figure 6-13 for BEHP.

  DGI probe data for inorganics in RA 3 are likely to be false positive analytical results (including pending COC cadmium). Boeing and USEPA will review the inorganics data from POC wells in RA 3 to determine the appropriate course of action using the Adaptive Management process for inorganics presented in Figure 6-12.

- **ERD.** ERD is applicable for remediation of cVOCs represented by groundwater exceedance areas cVOC-10 and cVOC-11 in RA 3. Historically, Boeing has successfully implemented ERD at OA 12 and in the 2-66 Sheetpile (RA 4). Boeing is currently successfully implementing ERD in the 2-10 North Sheetpile (RA 1), the 2-10 South Sheetpile (RA 2), and the EMF Plume. Analytical data demonstrate that ERD has achieved significant reductions in contaminant concentrations and mass every time it has been implemented at Plant 2.

  ERD corrective actions were previously conducted in RA 3 as part of the site demolition and redevelopment work. As presented above the 3DMe™ product was added to the

shallow groundwater to stimulate the aquifer to become more geochemically reducing and initiate ERD, which has been demonstrated to be capable of achieving the cleanup goal of bringing cVOC concentrations into compliance with their FMCLs. If warranted (based on results of the pre-design investigation to evaluate current groundwater conditions in RA 3) ERD would be a continuation of that corrective action.

- **Air Sparging/Soil Vapor Extraction (AS/SVE).** Air sparging combined with soil vapor extraction (SVE) is an applicable technology for remediation of cVOCs in groundwater. AS/SVE would consist of installing an active system to extract cVOC vapors from the subsurface in exceedance areas cVOC-10 and cVOC-11 and passing them through an aboveground air treatment system to remove contaminants prior to discharge to the atmosphere. Implementation of AS/SVE would cause aquifer geochemistry to become aerobic, which would halt ongoing ERD remediation. In addition, at the anticipated low cVOC concentrations based on soil excavation and initiating ERD, air sparging is not likely to be the most efficient remedial technology for cVOCs in RA 3. In contrast to RA 1 and RA 2, ERD substrate has not been replenished at RA 3 and conditions favorable for ERD have not been confirmed; therefore, consideration of AS/SVE is warranted.

In addition to the remedial technologies applicable to cVOCs, Adaptive Management processes are reserved to address the potential need for groundwater corrective measures for inorganics, organics, and PCBs:

- **Adaptive Management for Inorganics in Groundwater**. The potential for groundwater treatment technology has been retained for the inorganic constituents represented by exceedance areas Arsenic-4, Arsenic-5, CuZn-10, Cadmium-3, and Cadmium-4. These exceedance areas are well-delineated and, in some cases, appear stable or decreasing. Although the data for each area vary, the inorganic constituents have generally not been detected at concentrations greater than FMCLs downgradient at the POC, except FMCL exceedances for cadmium in samples from PL2-621A (Cadmium-3). Nickel detected at PL2-621A may be included under the adaptive management process if not adequately addressed under Short-Term Groundwater Monitoring. Ongoing groundwater monitoring data considered through the Adaptive Management process will indicate if any specific corrective action for one or more of these exceedance areas is warranted.

  Where Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations. The Adaptive Management process for inorganic COCs is shown graphically on Figure 6-12.

- **Adaptive Management for Organics in Groundwater.** The potential for groundwater treatment technology has been retained for the organic constituents represented by exceedance areas cVOC-10 and cVOC-11. Exceedance area cVOC-10 extends to POC wells PL2-620A and PL2-621A, which have FMCL exceedances for TCE and VC.

  Implementation of the proposed corrective measures is expected to achieve FMCLs for these exceedance areas; however, there might be some POC locations that do not achieve or consistently maintain FMCLs over time for organic COCs. A suitable corrective action technology will only be considered if groundwater monitoring data indicate that further consideration of corrective action for one or more of these exceedance areas is warranted.

Where Adaptive Management for organics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective technology determinations. The Adaptive Management process for organic COCs is shown graphically on Figure 6-13.

- **Adaptive Management for PCBs in Groundwater.** The potential for groundwater treatment technology and additional groundwater monitoring using the current analytical method has been retained for PCBs at shoreline monitoring well PL2-621A. Boeing will continue to analyze for PCB Aroclors in groundwater at this location using USEPA Method 8082A with an MDL of approximately 0.01 µg/L and will compare those data to PQL of 0.1 µg/L. After completion of eight semiannual monitoring events, Boeing may request an Adaptive Management response to the data collected from this well.

  In the future, Boeing will conduct PCB analysis in groundwater using a high-sensitivity analytical method (e.g., USEPA Method 1668) to achieve a reporting limit equal to or lower than the WQS, which is the TMCL for PCBs. Future monitoring for PCBs under this scenario is presented in RA 7 under Short-Term Groundwater Monitoring.

Because these future requirements have significant uncertainties, the Adaptive Management processes for PCBs cannot be represented graphically.

6.8.2 Remedial Alternatives for RA 3

Applicable remedial technologies for soil and groundwater in RA 3 have been assembled into remedial alternatives that are based on media, constituent, and location-specific considerations. In addition to impacted groundwater, the remedial alternatives consider concentrations of cDCE, TCE, cadmium, and PCBs exceeding the leaching SLs in soil.

With the exception of Alternative 1 below, the potential for considerable change in the soil and groundwater conditions in RA 3 requires an initial pre-design soil and groundwater sampling event using a direct push probe rig, in order to establish the current extent and concentrations of COCs in the RA 3 exceedance areas. Assembled groups of remedial technologies are identified below as numbered alternatives and are summarized in Table 6-3B.

Alternative 1 – Corrective Action Not Required with Controls: This remedial alternative is applicable for areas with no active measures, but where the following remedial technologies are used:

- No Corrective Action
- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics, BEHP, and PCBs

Alternative 1 requires no additional active corrective actions for soil, as long as the existing pavement remains in place or post-IM testing indicates that TCE and cDCE in soil is no longer a source to groundwater. Alternative 1 would utilize remedial technologies that are currently in place, including Engineering Controls and Institutional Controls. This alternative depends on the success of the bio/chemical degradation processes in groundwater, which have been enhanced

by source removal and addition of a nutrient substrate, performed as an IM to remediate the organic constituents present in RA 3. The protectiveness of this alternative will be evaluated with short- and long-term groundwater monitoring in the shoreline monitoring wells. This alternative serves as the baseline for comparison to other alternatives.

Alternative 2 – ERD: This remedial alternative adds ERD to Alternative 1 and would be expected to decrease the restoration timeframe relative to Alternative 1. Alternative 2 includes the following remedial technologies:

- ERD
- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics, BEHP, and PCBs

In addition to long- and short-term groundwater monitoring performed in the shoreline monitoring wells within RA 3, this alternative would likely require additional monitoring in existing and/or new wells to evaluate the performance of the ERD remedial technology.

Alternative 3 – AS/SVE: This remedial alternative includes the following remedial technologies:

- AS/SVE
- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics, BEHP, and PCBs

In addition to long- and short-term groundwater monitoring performed in the shoreline monitoring wells within RA 3, additional existing and new wells would likely be used to implement and monitor the performance of the AS/SVE remedial technology.

Alternative AM-1 – Adaptive Management for Inorganics in Groundwater: The Adaptive Management process for inorganics might be combined with any of the previously described alternatives as noted in Table 6-3A. Adaptive Management would be considered if future shoreline monitoring data indicate that inorganic COCs are present at concentrations exceeding FMCLs in groundwater at the POC as described in Section 6.3.8 and Figure 6-12. Where Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations.

Alternative AM-2 – Adaptive Management for Organics in Groundwater: The Adaptive Management process for organics might be combined with any of the previously described alternatives as noted in Table 6-3A. Adaptive Management would be considered if future shoreline monitoring data indicate that organic COCs are present at concentrations exceeding FMCLs in groundwater at the POC as described in Section 6.3.8 and Figure 6-13. Where

Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations.

Alternative AM-3 – Adaptive Management for PCBs in Groundwater: The Adaptive Management process for PCBs might be combined with any of the previously described alternatives as noted in Table 6-3A. Adaptive Management would be considered if future shoreline monitoring data indicate that PCBs are present at concentrations exceeding FMCLs in groundwater at the POC as described in Section 6.3.8. Where Adaptive Management for PCBs is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations.

6.8.3 RA 3 – Remedial Alternative Descriptions and Total Net Benefit Ratings

A summary table rating how effectively the proposed remedial alternatives meet RCRA Alternative Evaluation Standards and other factors is presented as Table 6-3C. Descriptions of the proposed elements and scopes of work for the RA 3 remedial alternatives are presented in Attachment S6C.

Alternative 1: Corrective Action Not Required with Controls – Alternative 1 is based on establishing an environmental covenant for the site and utilizing existing engineering controls including security fencing, pavement, and stormwater management to control exposure pathways to the environment. Alternative 1 also includes short-term and long-term groundwater monitoring at the POC (i.e., shoreline monitoring). The total net benefit rating for Alternative 1 is 21, as noted in Table 6-3C.

Alternative 2: ERD – Groundwater upgradient of the POC wells in RA 3 has not been sampled since the 2-31 Area DGI was performed in 2009. Since that time excavation was performed and ERD was initiated. As a result, soil and groundwater conditions in RA 3 are likely improved from the conditions presented in the 2-31 Area DGI. Understanding the current soil and groundwater conditions in RA 3 requires an initial pre-design soil and groundwater sampling event using a direct push probe rig to establish the current extent and concentrations of COCs in the RA 3 exceedance areas. Necessary adjustments to the scope and design of the alternative would be made based on results of this sampling.

ERD would be implemented at RA 3 by injecting a nutrient solution containing approximately 6 to 12 percent sugar solution with other micronutrients in potable water, or equivalent, into six new 4-inch-diameter A-Level injection wells. The addition of this organic carbon source is intended to stimulate bacteria to consume the available DO, which would favor population growth of anaerobic bacteria that are capable of reductively dechlorinating cVOCs- dissolved in groundwater in RA 3. The proposed ERD remedy assumes annual nutrient injections over 5 years to maintain geochemical conditions favorable for ERD.

The institutional and engineering controls and long-term and short-term monitoring described above for Alternative 1 also apply to Alternative 2. Proposed groundwater monitoring specific to the ERD remedy in RA 3 includes semiannual groundwater monitoring in six new injection wells, three new monitoring wells, and four existing shoreline monitoring wells with semiannual reporting. The number and locations of the new injection and monitoring wells are dependent on results of the initial pre-design soil and groundwater sampling event for RA 3. The total net benefit rating for Alternative 2 is 25, as noted in Table 6-3C.

Alternative 3: AS/SVE – Implementation of AS/SVE in RA 3 also requires an initial pre-design soil and groundwater sampling event using a direct push probe rig to establish the current extent and concentrations of COCs in the RA 3 exceedance areas. Necessary adjustments to the scope and design of the alternative would be made based on results of this sampling.

AS/SVE would be implemented at RA 3 by installing five new A-Level, 2-inch-diameter AS wells in a transect perpendicular to groundwater flow across the cVOC-10 exceedance area. The AS/SVE system also includes 10 new shallow SVE wells and 3 new A-Level monitoring wells. Alternative 3 would require rental or purchase and modification of one AS equipment trailer and one SVE equipment trailer. The alternative would also require that electrical lines and air piping be installed and connected to and from the AS/SVE equipment.

The proposed AS/SVE remedy assumes operation, maintenance, and monitoring of the AS/SVE system over a period of 5 years to reach FMCLs and to test for and remove rebound effects. Operational tasks include semiannual off-gas sampling at pre- and post-activated carbon treatment sample ports, annual change-out of activated carbon filtration media, monthly site visits, and annual maintenance of the system.

The institutional and engineering controls and long-term and -short-term monitoring described above for Alternative 1 also apply to Alternative 3. Proposed groundwater monitoring specific to the AS/SVE remedy in RA 3 assumes semiannual groundwater monitoring in the five new AS wells and three new downgradient monitoring wells for 5 years with semiannual reporting for 5 years. Vapor samples would also be taken semiannually from each of the assumed 10 SVE wells and from the post-treatment sampling point to evaluate if GAC replacement is required. The total net benefit rating for Alternative 3 is 20, as noted in Table 6-3C.

Alternative AM-1: Adaptive Management for Inorganics in Groundwater – If the Adaptive Management process for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations as shown in Figure 6-12. The appropriate strategy resulting from this process cannot be known or evaluated at this time.

Alternative AM-2: Adaptive Management for Organics in Groundwater – If the Adaptive Management process for organics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations as shown in Figure 6-13. The appropriate strategy resulting from this process cannot be known or evaluated at this time.

Alternative AM-3: Adaptive Management for PCBs in Groundwater – If the Adaptive Management process for PCBs is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations. The appropriate strategy resulting from this process cannot be known or evaluated at this time.

6.8.4 RA 3 – Recommended Remedial Alternative

As summarized in Table 6-3C, the remedial alternative with the greatest total net benefit is Alternative 2 (ERD) with a result of 25 out of a possible 30. In addition, previous implementations of ERD IMs at Plant 2 have demonstrated that this technology is effective and highly implementable. Comparatively, the estimated cost for implementation of Alternative 2 is not

prohibitive and implementation of ERD provides substantial benefit. Therefore, Alternative 2 is the recommended remedial alternative for RA 3.

A conceptual design layout for the injection well network in RA 3 is presented in Figure 6-5B. As noted in the preceding section, the number and locations of the new injection and monitoring wells are dependent on results of the initial pre-design soil and groundwater sampling event for RA 3.

Alternative 2 is designed to remediate the cVOC groundwater exceedance areas present in RA 3 but it does not directly remediate the inorganic exceedance areas in RA 3. Successful completion of Alternative 2 is expected to allow groundwater to return to natural geochemical conditions, which should reduce metals concentrations within approximately 5 years. If future shoreline monitoring data indicate inorganic, organic, or PCB FMCL exceedances in groundwater, then Alternatives AM-1, AM-2, or AM-3, respectively, would be pursued in coordination with EPA.

Supporting technical discussions and rationale for the rating assigned to each of the RCRA Alternative Evaluation Standards are presented in Attachment S6C.

6.9 RA 4 – 2-66 Sheetpile- and Surrounding Area

RA 4 contains the 2-66 Area, which includes portions of the paved industrial area and unpaved shoreline area, and the western portion of the 2-60 Area (paved industrial). RA 4 consists of groundwater with concentrations exceeding the FMCLs (TMCLs for petroleum hydrocarbons) for cVOCs, BTEX, naphthalene, arsenic, copper, zinc, cadmium, free cyanide, GRPH, and DRPH (Figure 6-6A and Table 6-4A).

The original sources of cVOC contamination at RA 4 are thought to have been the TCE degreaser associated with RCRA Unit AOC 2-66.53 and a leaking TCE storage tank. The TCE storage tank was decommissioned in the late 1980s, and the area with the greatest cVOC concentration in soil and groundwater was surrounded by a steel sheetpile containment structure to block cVOC (TCE, cDCE, and VC) migration to the waterway.

RA 4 has been subjected to several IMs described in Sections 3.1, 3.3, 4.1, and Attachments S3A and S3C. Groundwater upgradient of the POC in RA 4 has not been extensively sampled since the 2-66 Area DGI was performed in 2006. Since that time, IMs were performed and source excavation was completed inside of the 2-66 Sheetpile. A significant volume of vadose-zone soil was also excavated and disposed of offsite for duct bank and stormwater swale installation, and for Southwest Bank cutback. As a result, soil and groundwater conditions in RA 4 are likely improved compared to conditions presented in the 2-66 Area DGI Report. Understanding the current extent and concentrations of COCs in the RA 4 exceedance areas may require an initial pre-design soil and groundwater sampling event using a direct push probe rig. Necessary adjustments to the scope and design of the selected remedial alternative would be made based on results of this sampling. Currently, groundwater samples are obtained semiannually from shoreline monitoring wells PL2-614A, PL2-614B, PL2-615A, PL2-616A, and PL2-617A, which are completed at the POC within RA 4.

Groundwater exceedance areas in the Southwest Bank have been removed by excavation of the soil/sediment sources as part of the DSOA remedy that was performed in this area. The removal actions removed former exceedance areas for copper, zinc, cadmium, and

RA 4 – 2-66 Sheetpile and Surrounding Area

Key Features

The 2-66 Area is combined with the western half of the 2-60s Area and includes portions of the paved and unpaved shoreline areas and the Habitat Area.

COCs Driving Remedy Selection

Groundwater: cVOCs (TCE, cDCE, and VC)

Soil: TCE, PCBs, and cPAHs

Considerations Affecting Remedy Selection: cVOCs formerly present in soil were removed by excavation to groundwater inside of the 2-66 Sheetpile. A remediation substrate, 3DMe™, was applied to the top of the groundwater prior to backfilling. Exceedance areas in the Southwest Bank have been removed by excavation as noted in Figure 6-6.

Metal groundwater exceedance areas are suspected to be comprised of false positive results on the basis of data collection or analysis methods.

RCRA Units Associated with Current RA Corrective Action(s)

AOC 2-66.53, AOC 2-66.52

AOC 2-108.73, AOC 2-108.72

OA 1, OA 2, OA 9, OA 12, OA 14, OA 19

SWMU 2-64.48, SWMU 2-64.49

SWMU 2-65-.50, SWMU 77.B

SWMU 78.C, SWMU 2-70.55

POC Monitoring Wells

PL2-614A, PL2-614B, PL2-615A,

PL2-615B, PL2-616A, PL2-617A

PCBs. The former groundwater exceedance areas originated from sources in the contaminated fill in the Southwest Bank that has been removed and are listed in Table 6-4A solely for historical context.

RA 4 contains groundwater with COC concentrations exceeding the FMCLs for cVOCs, BTEX, naphthalene (included with DRPH), arsenic, CuZn, and GRPH (included with BTEX), and DRPH that are greater than their respective TMCLs/FMCLs. Exceedance areas for these constituents are identified in Table 6-4A and presented in the various figures identified below. Pending COCs cadmium and free cyanide were also identified in this RA at concentrations worthy of further evaluation under the short-term groundwater monitoring process outlined in Section 6.3.5.

Constituent Exceedance Area	**Associated Figures**
cVOC-4, cVOC-5, and cVOC-6	Figures 4-2D and 6-6B
BTEX-4 and BTEX-5	Figures 4-3D and 6-6B
Arsenic-2	Figures 4-4D and 6-6B
CuZn-2, CuZn-4 through CuZn-7	Figures 4-5D and 6-6B
Cyanide-4 and Cyanide-5	Figures 4-6D and 6-6B
DRPH-3 and DRPH-5	Figures 4-7D and 6-6B
Cadmium-1 and Cadmium-2	Figures 4-10D and 6-6B

Exceedance areas Arsenic-2, CuZn-2, and CuZn-4 through CuZn-7 are based almost exclusively on probe data, which are commonly turbid and potentially result in false positives, especially for constituents such as metals that tend to adsorb to particulates suspended in turbid probe samples.

There are no sample locations with concentrations of COCs exceeding the FMCLs for soil within RA 4. Concentrations of cPAH, TCE, and PCBs exceeding the leaching SLs were identified between 8 and 10 feet bgs (exceedance locations and concentrations are presented in Figure 6-6A).

Figure 6-6B presents the proposed remedial alternative for RA 4 to support the discussion in the sections that follow. A CSM cross section for RA 4 depicting hydrogeologic conditions based on data through January 2013 is presented in Figure 6-6C. The east-west cross section alignment for the RA 4 CSM is shown on Figure 6-6B.

6.9.1 Applicable Remedial Technologies for RA 4

Remedial alternatives for RA 4 would address the presence of cVOCs and specific metals that exceed soil or groundwater FMCLs associated with the 2-66 Sheetpile and surrounding area. The constituents or constituent groups that have been detected in soil or groundwater at concentrations greater than applicable leaching SL for soil and FMCLs for groundwater in RA 4 are presented in Table 6-4A and Figure 6-6A. Table 6-4A identifies the technologies that were considered to address the COCs present in RA 4. Applicable technologies are described in the text that follows:

- **Engineering Controls.** Existing pavement in the paved industrial area of RA 4 serves as a physical barrier to direct contact with soil containing TCE concentrations above the leaching SLs, which could contribute to groundwater exceedance area cVOC-5. RA 4 is physically accessible to site workers only. Public exposure would be prevented by physical barriers (e.g., fencing and Boeing security). These structures must remain in place and operational until soil and groundwater results are in compliance with the FMCLs.
- **Institutional Controls.** Institutional controls in the form of an environmental covenant would require approximately three quarters of RA 4 to be covered by pavement or a building. The remaining quarter of RA 4 lies within the unpaved shoreline area. These controls would be consistent with the technology description presented in Section 6.3 and Attachment S5A.
- **Long-Term Groundwater Monitoring.** Shoreline monitoring wells PL2-614A, PL2-614B, PL2-615A, PL2-615B, PL2-616A, and PL2-617A are installed at the POC within RA 4 and would continue to be monitored on a semiannual schedule as part of the shoreline monitoring program as described in Attachment S6A.
- **Short-Term Groundwater Monitoring.** Boeing proposes to sample well PL2-615A for free cyanide over four semiannual shoreline monitoring events (Table 2-1 and Attachment S2B). If there are no exceedances of the proposed FMCL for free cyanide after four shoreline events have been completed, free cyanide results will be evaluated without the use of statistics to evaluate if continued free cyanide monitoring is warranted at this location. If there are exceedances of the proposed FMCL for free cyanide PL2-615A will be analyzed for free cyanide for a total of eight events and those data will be evaluated using the 95% UCL statistical evaluation. Additional details are presented in Attachment S2B.

  Well PL2-617A is located downgradient of tunnels backfilled with crushed concrete. Although the crushed concrete was placed above the groundwater table. PL2-617A was sampled for PCBs for four semiannual shoreline monitoring events, ending in March 2017. PCB data from PL2-617A were consistently non-detect throughout the four events. Boeing discontinued PCB sampling at PL2-617A. Additional information regarding PCB analysis is presented in Section 6.8.3, Adaptive Management for PCBs.

  DGI probe data for inorganics in RA 4 are likely to be false positive analytical results. However, copper has been detected at concentrations exceeding the FMCL at two monitoring locations downgradient of the copper exceedance areas in this RA (PL2-614A and PL2-617A). These detections are infrequent among recent sampling results: both wells have been sampled six times, with only one result that exceeds the copper FMCL in either well. Boeing and USEPA will review the inorganics data from POC wells in RA 4 to determine the appropriate course of action using the Adaptive Management process for inorganics presented in Figure 6-12.
- **ERD**. ERD is applicable for remediation of cVOCs represented by groundwater exceedance areas cVOC-4, cVOC-5, and cVOC-6 in RA 4. Boeing performed a soil excavation inside of the 2-66 Sheetpile as part of the site demolition and redevelopment work. This excavation work removed vadose-zone soil that was impacted by cVOCs and other contaminants. The excavation work performed inside the 2-66 Sheetpile is described in Section 3.0 and Attachment S3A. Residual groundwater impacts within the 2-66 Sheetpile were further treated by mixing the remediation substrate 3DMe™ to the top of the water table in the completed excavation prior to backfilling with clean fill material.

The 3DMe™ was added to stimulate the aquifer to become more geochemically reducing and initiate ERD, which has been demonstrated to be capable of achieving the cleanup goal of attaining cVOC concentrations that are less than their FMCLs. Boeing proposes to continue ERD in RA 4. The specific design features of how ERD will be implemented in RA 4 will be based on the results of a corrective action design investigation that will be performed as part of the CMI. The corrective action design investigation will provide additional site-specific data that are necessary to finalize the corrective action design for RA 4.

- **AS/SVE.** Air sparging is applicable for remediation of cVOCs, BTEX, naphthalene, and GRPH, which are represented by exceedance areas cVOC-4, cVOC-5, cVOC-6, BTEX-4, and BTEX-5. If air sparging is implemented at RA 4 it must be combined with SVE to remove the cVOC vapors generated by sparging. However, because ERD has already been initiated at RA 4 as an IM and with the addition of 3DMe™ to the top of the water table inside of the 2-66 Sheetpile, air sparging is likely not an efficient remedial technology for the residual cVOC concentrations.

  In addition, implementation of air sparging would cause the aquifer geochemistry to become aerobic, which would halt ERD. At the anticipated low cVOC concentrations based on soil excavation and initiating ERD, air sparging is not likely to be the most efficient remedial technology for cVOCs in RA 4. However, unlike RA 1 and RA 2, there are cVOC areas outside the sheetpile that have not undergone ERD; therefore, consideration of AS/SVE is warranted.

- **Excavation with Off-Site Disposal.** Excavation is considered a potential technology at RA 4 because of historic management of RCRA Unit AOC 2-66.52, TCE Degreaser. Excavation of soil outside the 2-66 Sheetpile that exceeds the leaching SLs for cVOCs and potentially impacts groundwater exceedance area cVOC-5 would be performed if groundwater cleanup levels cannot be achieved by ERD or AS/SVE. The depth of the excavation is anticipated to be approximately 10 feet bgs, resulting in the removal of approximately 360 cy of soil. This estimate of soil volume could change based on the confirmation soil sampling results.

  If soil data results from the RA 4 initial pre-design soil and groundwater sampling (described in Section 6.9.2 and Attachment S6C) establish that soil concentrations are below FMCLs, soil excavation might not be required.

In addition to the remedial technologies applicable to cVOCs, Adaptive Management processes are retained to address the potential need for groundwater corrective measures for inorganics, organics, and PCBs:

- **Adaptive Management for Inorganics in Groundwater**. The potential for groundwater treatment technology has been retained for the inorganic constituents represented by exceedance areas Arsenic-2, CuZn-2, CuZn-4 through CuZn-7, Cadmium-1, Cadmium-2, Cyanide-4, and Cyanide-5. These exceedance areas are well-delineated and, in some cases, appear stable or decreasing. Although the data for each area vary, the inorganic constituents have generally not been detected at concentrations greater than FMCLs downgradient at the POC, except FMCL exceedances for arsenic in PL2-615A exceedances for cadmium in PL2-614A, and infrequent exceedances for copper in PL2-614A and PL2-617A. Ongoing groundwater monitoring data considered through the

Adaptive Management process will indicate if any specific corrective action for one or more of these exceedance areas is warranted.

Where Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations. The Adaptive Management process for inorganic COCs is shown graphically on Figure 6-12.

- **Adaptive Management for Organics in Groundwater.** The potential for groundwater treatment technology has been retained for the organic constituents represented by exceedance areas cVOC-4, cVOC-5, and cVOC-6. These exceedance areas are generally well delineated, and only TCE has commonly been detected at concentrations greater than its FMCL at POC monitoring wells PL2-614A and PL2-616A.

  Implementation of the proposed corrective measures is expected to achieve FMCLs for these exceedance areas; however, there might be some POC locations that do not achieve or consistently maintain FMCLs over time for organic COCs. A suitable corrective action technology will only be considered if groundwater monitoring data indicate that further consideration of corrective action for one or more of these exceedance areas is warranted.

  Where Adaptive Management for organics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective technology determinations. The Adaptive Management process for organic COCs is shown graphically on Figure 6-13.

- **Adaptive Management for PCBs in Groundwater.** The potential for groundwater treatment technology and additional groundwater monitoring has been retained for PCBs. As outlined above in Short-Term Groundwater Monitoring, PCBs have been analyzed for four semiannual events at shoreline monitoring well PL2-617A, with no PCB detections using the current analytical method.

  In the future, Boeing will conduct PCB analysis in groundwater using a high-sensitivity analytical method (e.g., USEPA Method 1668) to achieve a RL equal to or lower than the WQS, which is the TMCL for PCBs. Future monitoring for PCBs under this scenario is presented in RA 7 under Short-Term Groundwater Monitoring.

6.9.2 Remedial Alternatives for RA 4

Applicable remedial technologies for soil and groundwater in RA 4 have been assembled into remedial alternatives that are based on media, constituent, and location-specific considerations. The remedial alternatives consider the presence of TCE in soil at concentrations greater than the leaching SLs as a potential source to groundwater for soils that are outside of the 2-66 Sheetpile. Vadose-zone soil inside of the 2-66 Sheetpile was excavated to the water table and disposed offsite as part of the 2010-2012 demolition and redevelopment work. Assembled groups of remedial technologies are identified as numbered alternatives that are described below and are summarized in Table 6-4B.

With the exception of Alternative 1, the changed soil and groundwater conditions in RA 4 require an initial pre-design soil and groundwater sampling event using a direct push probe rig to establish

the current extent and concentrations of COCs in the RA 4 exceedance areas. The results of this sampling may lead to adjustments to the scope and design of the selected remedial alternative.

Alternative 1 – Corrective Action Not Required with Controls: This remedial alternative is applicable for areas with no active measures, but where the following remedial technologies are used:

- No Corrective Action
- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics and PCBs

Alternative 1 requires no additional active corrective actions for soil, as long as the existing pavement remains in place and indefinitely if post-IM testing indicates that TCE in soil is no longer a source to groundwater. However, Alternative 1 would utilize remedial technologies that are currently in place, including Engineering Controls and Institutional Controls. This alternative depends on the success of the bio/chemical degradation processes, which have been enhanced by the current IM to remediate the organic constituents present in RA 4. The protectiveness of this alternative would be evaluated with short- and long-term groundwater monitoring in the shoreline monitoring wells. This alternative serves as the baseline for comparison to other alternatives.

Alternative 2 – ERD: This remedial alternative adds ERD to Alternative 1 and would be expected to decrease the restoration timeframe relative to Alternative 1. Alternative 2 includes the following remedial technologies:

- ERD
- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics and PCBs

In addition to long- and short-term groundwater monitoring performed in the shoreline monitoring wells within RA 4, this alternative would likely require additional monitoring in existing and/or new wells to evaluate the performance of the ERD remedial technology.

Alternative 2a – ERD and Excavation with Off-Site Disposal: This remedial alternative adds excavation with off-site disposal to Alternative 2 and would be expected to decrease the restoration timeframe relative to Alternative 2. Alternative 2a includes the following remedial technologies:

- Excavation with Off-Site Disposal
- ERD

- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics and PCBs

In addition to long- and short-term groundwater monitoring performed in the shoreline monitoring wells within RA 4, this alternative would likely require additional monitoring in existing and/or new wells to evaluate the performance of the ERD remedial technology.

Alternative 3 – AS/SVE: This remedial alternative includes the following remedial technologies:

- AS/SVE
- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics and PCBs

In addition to long- and short-term groundwater monitoring performed in the shoreline monitoring wells within RA 4, additional existing and new wells would likely be used to implement and monitor the performance of the AS/SVE remedial technology.

Alternative 3a – AS/SVE and Excavation with Off-Site Disposal: This remedial alternative adds excavation with off-site disposal to Alternative 3 and would be expected to decrease the restoration timeframe relative to Alternative 3. This alternative includes the following remedial technologies:

- Excavation with Off-Site Disposal
- AS/SVE
- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics and PCBs

In addition to long- and short-term groundwater monitoring performed in the shoreline monitoring wells within RA 4, additional existing and new wells would likely be used to implement and monitor the performance of the AS/SVE remedial technology.

Alternative AM-1 – Adaptive Management for Inorganics in Groundwater: The Adaptive Management process for inorganics might be combined with any of the previously described alternatives as noted in Table 6-4A. Adaptive Management would be considered if future shoreline monitoring data indicate that inorganic COCs are present at concentrations exceeding FMCLs in groundwater at the POC as described in Section 6.3.8 and Figure 6-12. Where Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek

approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations.

Alternative AM-2 – Adaptive Management for Organics in Groundwater: The Adaptive Management process for organics might be combined with any of the previously described alternatives as noted in Table 6-4A. Adaptive Management would be considered if future shoreline monitoring data indicate that organic COCs are present at concentrations exceeding FMCLs in groundwater at the POC as described in Section 6.3.8 and Figure 6-13. Where Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations.

Alternative AM-3 – Adaptive Management for PCBs in Groundwater: The Adaptive Management process for PCBs might be combined with any of the previously described alternatives as noted in Table 6-4A. Adaptive Management would be considered if future shoreline monitoring data indicate that PCBs are present at concentrations exceeding FMCLs in groundwater at the POC as described in Section 6.3.8. Where Adaptive Management for PCBs is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations.

6.9.3 RA 4 – Remedial Alternative Descriptions and Total Net Benefit Ratings

A summary table rating how effectively the proposed remedial alternatives meet RCRA Alternative Evaluation Standards and other factors is presented as Table 6-4C. Descriptions of the proposed elements and scopes of work for the RA 4 remedial alternatives are presented in Attachment S6C.

Alternative 1: Corrective Action Not Required with Controls – Alternative 1 is based on establishing an environmental covenant for the site and utilizing existing engineering controls including security fencing, pavement, and stormwater management to control exposure pathways to the environment. Alternative 1 also includes short- and long-term groundwater monitoring at the POC (i.e., shoreline monitoring). The total net benefit rating for Alternative 1 is 21, as noted in Table 6-4C.

Alternative 2: ERD – ERD would be implemented at RA 4 by injecting a nutrient solution containing approximately 6 to 12 percent sugar solution with other micronutrients in potable water, or equivalent, into 15 new 4-inch-diameter, A-Level injection wells. The addition of this organic carbon source is intended to stimulate bacteria to consume the available DO, which would favor population growth of anaerobic bacteria that are capable of reductively dechlorinating cVOCs dissolved in groundwater in RA 4. The proposed ERD remedy assumes annual nutrient injections over a period of 5 years to maintain geochemical conditions favorable for ERD.

The institutional and engineering controls and long- and short-term monitoring described above for Alternative 1 also apply to Alternative 2. Proposed groundwater monitoring specific to the ERD remedy in RA 4 includes semiannual groundwater monitoring in 15 new injection wells, and six existing shoreline monitoring wells with semiannual reporting. The number and locations of the new injection wells are dependent on results of the initial pre-design soil and groundwater sampling event for RA 4. The total net benefit rating for Alternative 2 is 25, as noted in Table 6-4C.

Alternative 2a: ERD and Excavation with Off-Site Disposal – As noted for Alternative 2 above, excavation followed by ERD requires an initial soil and groundwater sampling event to establish

the current extent and concentrations of COCs in the RA 4 exceedance areas. Necessary adjustments to the scope and design of the alternative would be made based on results of this sampling event.

ERD would be implemented as described above for Alternative 2 with the addition of direct application of a remediation substrate such as 3DMe™, or equivalent, into the excavation prior to backfilling. The institutional and engineering controls, long-term, and short-term monitoring described above for Alternative 1 also apply to Alternative 2a and are assumed to be the same as for Alternative 2. The total net benefit rating for Alternative 2a is 24, as noted in Table 6-4C.

Alternative 3: AS/SVE – As noted above, AS/SVE requires an initial pre-design soil and groundwater sampling event using a direct push probe rig to establish the current extent and concentrations of COCs in the RA 4 exceedance areas. Necessary adjustments to the scope and design of the alternative would be made based on results of this sampling event.

AS/SVE would be implemented at RA 4 by installing six new A-Level, 2-inch-diameter AS wells and 12 new shallow SVE wells in a transect perpendicular to groundwater flow across the width of exceedance area cVOC-5. Alternative 3 would require rental or purchase and modification of one AS equipment trailer and one SVE equipment trailer or skid-mounted blower. The alternative would also require that electrical lines and air piping be installed and connected to and from the AS/SVE equipment.

The institutional and engineering controls and long and short-term monitoring described for Alternative 1 also apply to Alternative 3. The proposed AS/SVE remedy assumes operation, maintenance, and monitoring of the AS/SVE system over a period of 5 years to reach FMCLs and to test for and remove rebound effects. Operational tasks include semiannual off-gas sampling at pre- and post-activated carbon treatment sample ports, semiannual change out of activated carbon filtration media for the first 2 years and annually for the next 3 years, monthly site visits, and annual maintenance of the system. Proposed groundwater monitoring specific to the AS/SVE remedy in RA 4 assumes semiannual groundwater monitoring in the six new AS wells and six existing shoreline monitoring wells with semiannual reporting for 5 years.

Vapor samples would also be taken semiannually from each of the assumed 12 SVE wells and from the post-treatment sampling point to evaluate if GAC replacement is required.

The total net benefit rating for Alternative 3 is 20 as noted in Table 6-4C.

Alternative 3a: AS/SVE and Excavation with Off-Site Disposal – As noted for Alternative 3 above, excavation followed by AS/SVE requires an initial soil and groundwater sampling event to establish the current extent and concentrations of COCs in the RA 4 exceedance areas. Necessary adjustments to the scope and design of the alternative would be made based on results of this sampling event.

AS/SVE would be implemented as described above for Alternative 3. The institutional and engineering controls and long- and short-term monitoring described above for Alternative 1 also apply to Alternative 3a and are assumed to be the same as for Alternative 3.

The total net benefit rating for Alternative 3a is 19, as noted in Table 6-4C.

Alternative AM-1: Adaptive Management for Inorganics in Groundwater – If the Adaptive Management process for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations as shown in Figure 6-12. The appropriate strategy resulting from this process cannot be known or evaluated at this time.

Alternative AM-2: Adaptive Management for Organics in Groundwater – If the Adaptive Management process for organics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations as shown in Figure 6-13. The appropriate strategy resulting from this process cannot be known or evaluated at this time.

Alternative AM-3: Adaptive Management for PCBs in Groundwater – If the Adaptive Management process for PCBs is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations. The appropriate strategy resulting from this process cannot be known or evaluated at this time.

6.9.4 RA 4 – Recommended Remedial Alternative

As summarized in Table 6-4C, the remedial alternative with the greatest total net benefit is Alternative 2, ERD, with a result of 25 out of a possible 30. In addition, previous ERD IMs inside of the 2-66 Sheetpile and at other locations at Plant 2 have demonstrated that this technology is effective and highly implementable. Comparatively, the estimated cost for implementation of Alternative 2 is not prohibitive and ERD provides substantial benefit. Therefore, Alternative 2, ERD without soil excavation, is the recommended remedial alternative for RA 4.

A conceptual design layout for the injection well network in RA 4 is presented in Figure 6-6B. As noted in the preceding section, the number and locations of the new injection and monitoring wells are dependent on results of the initial pre-design soil and groundwater sampling event for RA 4.

Alternative 2 is designed to remediate the cVOC groundwater exceedance areas present in RA 4 but it does not directly remediate the inorganic exceedance areas in RA 4. Successful completion of Alternative 2 is expected to allow groundwater to return to natural geochemical conditions, which should reduce inorganic concentrations within approximately 5 years. If future shoreline monitoring data indicate inorganic or organic FMCL exceedances in groundwater, then Alternatives AM-1 or AM-2 respectively, would be pursued in coordination with EPA.

Supporting technical discussions and rationale for the rating assigned to each of the RCRA Alternative Evaluation Standards are presented in Attachment S6C.

6.10 RA 5 – South Yard Area

RA 5 encompasses an area within the paved industrial area along the southern boundary of Plant 2 and includes groundwater with concentrations of cVOCs, BTEX, arsenic, zinc, and DRPH that exceed their TMCLs/FMCLs (Figure 6-7A and Table 6-5A). PCBs and MoRPH are the only constituent groups detected in RA 5 soil samples at concentrations greater than the applicable FMCLs (Figure 6-7A and Table 6-5A). Six soil sample locations exceed the FMCL for MoRPH and one soil sample location exceeds the FMCL for PCBs in this large area. Concentrations of TCE, VC, benzene, ethylbenzene, cadmium, zinc, DRPH and PCBs exceeding the leaching SLs were identified between 7 and 11 feet bgs and are shown in Figure 6-7A.

The main source of cVOC impacts in RA 5, the former cisterns, was removed and excavated prior to the South Yard Area DGI. Based on South Yard Area DGI data from 2005 the concentrations of cVOCs and other COCs in RA 5 were relatively low and cover a relatively large area. The distribution of cVOC breakdown products throughout RA 5, specifically VC, indicates that reductive dechlorination of cVOCs is naturally-occurring in groundwater within this RA. It is likely that the extent and concentrations of cVOC exceedance areas have changed since the South Yard Area DGI was completed.

RA 5 contains groundwater exceedance areas identified as cVOC, benzene, arsenic, zinc, DRPH and MoRPH. The respective exceedance areas for these constituents are identified in Table 6-5A and presented in the figures identified below.

Exceedance Area	Associated Figures
cVOC-1 and cVOC-2	Figures 4-2D and 6-7A
BTEX-1 and BTEX-2	Figures 4-3D and 6-7A
Arsenic-1 and Arsenic-14	Figures 4-4D and 6-7A
CuZn-1	Figures 4-5D and 6-7A
DRPH-1 and DRPH-2	Figures 4-7D and 6-7A

RA 5 – South Yard Area

Key Features

Includes approximately the southern 75 percent of the South Yard Area, including most of the southern property boundary between Plant 2 and the Jorgensen Forge facility. RA 5 is entirely within the paved industrial area.

COCs Driving Remedy Selection

Groundwater: cVOCs (TCE and VC) and BTEX

Soil: MoRPH, cVOCs, and PCBs

Considerations Affecting Remedy Selection: cVOCs formerly present in soil and groundwater at the cisterns were removed by excavation to groundwater in 1999. cVOC concentrations in groundwater were low but covered a large area based on 2005 DGI data.

Metal groundwater exceedance areas are likely comprised of false positive results on the basis of data collection or analysis methods.

RCRA Units Associated with Current RA Corrective Action(s)

AOC 2-80.58, AOC 2-84.62

AOC 2-86.63, OA 3, OA 16,

SWMU 78.5, SWMU 2-91.70

SWMU 2-89.68, SWMU 2-80.56,

SWMU 2-80.57, SWMU 2-87.65

SWMU 78.B, SWMU 79.A

SWMU 79.B, SWMU 2-78.1

POC Monitoring Wells

PL2-613A, PL2-613B

Figure 6-7B presents the proposed remedial alternative for RA 5 to support the discussion in the sections that follow. The CSM cross section for RA 5 depicting hydrogeologic conditions is based on data through January 2013 is presented in Figure 6-7C. The east-west cross section alignment for the RA 5 CSM is shown on Figure 6-7B.

6.10.1 Applicable Remedial Technologies for RA 5

Remedial alternatives for RA 5 were designed to address the presence of cVOCs and specific metals in groundwater and MoRPH and PCB in soil that exceed FMCLs in the South Yard Area. The constituents or constituent groups that have been detected in soil or groundwater at concentrations greater than their applicable FMCLs in RA 5 are presented in Table 6-5A and Figure 6-7A. Table 6-5A identifies the technologies that were considered to address the COCs present in RA 5. Applicable technologies are described in the text that follows:

- **Engineering Controls.** Existing pavement and buildings in the paved industrial area serve as physical barriers to direct contact with soil containing MoRPH and PCB concentrations above FMCLs. Pavement and buildings also serve as physical barriers to soil with cVOC, BTEX, PCB, cadmium, and zinc concentrations above the leaching SLs, which could contribute to groundwater exceedance areas. RA 5 is physically accessible to site workers only. Physical barriers (e.g., fencing and Boeing security) would prevent public exposure. These structures must remain in place and operational until soil and groundwater results are in compliance with the FMCLs.
- **Institutional Controls.** Institutional controls in the form of an environmental covenant would require RA 5 to be covered by pavement or building(s).
- **Long-Term Groundwater Monitoring.** Property boundary wells in RA (i.e., PL2-112A, PL2-151A, PL2-156A, PL2-601A, PL2-601B, PL2-602A, PL2-602B, PL2-603A, and PL2-603B) would be used to monitor groundwater along the property boundary with Jorgensen Forge. In addition, proposed A- and B-Level shoreline monitoring wells at Location A (i.e., PL2-613A and PL2-613B), although outside of the RA 5 boundary, would be used to monitor groundwater at the POC for RA 5, although Location A is not within the RA 5 boundaries. Proposed wells at Location A would be monitored semiannually as part of the shoreline monitoring program. Property boundary wells would initially be monitored on a proposed schedule described in the CMI Work Plan for RA 5 and would revert to annual sampling when remediation goals outlined in the CMI Work Plan are met.
- **Short-Term Groundwater Monitoring.** Boeing proposes to sample wells PL2-601B, PL2-602B, and PL2-603B for zinc over four semiannual shoreline monitoring events (Table 2-1 and Attachment S2B). If there are no FMCL exceedances Boeing will evaluate the data without the use of statistics to determine if zinc should continue to be monitored at these locations. If there are FMCL exceedances for zinc those wells with exceedances will be sampled for zinc for a total of eight events and those data will be evaluated using the 95% UCL to determine if continued zinc monitoring is warranted.
- **ERD.** ERD is applicable for remediation of cVOCs represented by exceedance areas cVOC-1 and cVOC-2 in RA 5. ERD would be implemented at RA 5 by injecting a nutrient solution containing approximately 6 to 12 percent sugar solution with other micronutrients, in potable water into 10 new 4-inch diameter, A-Level injection wells and four new 4-inch-diameter, B-Level injection wells. The addition of this organic carbon source is intended to stimulate bacteria to consume the available DO, which would favor population growth

of anaerobic bacteria that are capable of reductively dechlorinating cVOCs that are dissolved in groundwater in RA 5, specifically in exceedance areas cVOC-1 and cVOC-2.

The proposed ERD remedy assumes annual nutrient injections in the 14 new injection wells over a period of 5 years to maintain geochemical conditions favorable for ERD. The institutional and engineering controls and long- and short-term monitoring described above for Alternative 1 also apply to Alternative 2. Proposed groundwater monitoring specific to the ERD remedy in RA 5 includes semiannual groundwater monitoring in 14 new injection wells and 9 existing RA 5 property boundary monitoring wells with semiannual reporting. A conceptual layout of the injection well network is provided in Figure 6-7B. However, the numbers and locations of the new injection and monitoring wells are dependent on results of the initial pre-design soil and groundwater sampling event for RA 5.

- **Enhanced Aerobic Degradation (EAD).** EAD is applicable for remediation of BTEX and DRPH represented by exceedance areas BTEX-1, BTEX-2, DRPH-1, and DRPH-2. This groundwater remedial technology has been successfully implemented at Plant 2 as an IM at OA 9, Former USTs PL-16, 17, and 18 to remediate an area with soil and groundwater impacted by BTEX and GRPH; this area was not amenable to excavation due to a large number of important underground utilities transecting the impacted area.

  EAD is incompatible with ERD because each technology is designed to drive the groundwater geochemistry in a different direction (aerobic rather than anaerobic); therefore, these two technologies should not be applied at the same time in the same location. The exceedance areas that are amenable to remediation using EAD are well delineated and are significantly smaller than the cVOC exceedance areas in RA 5. As a result, if warranted, the non-chlorinated VOC and fuel exceedance areas in RA 5 would be addressed after remediation of the more significant cVOC exceedance areas are completed. When ERD is completed at RA 5, EAD would be implemented at BTEX and DRPH exceedance areas by injecting a commercially available remediation substrate solution that releases oxygen into the A-Level of the aquifer. The remediation substrate would be injected in a grid pattern using a direct push probe rig. Oxygen releasing substrate would be injected into the A-Level of the aquifer at variable quantities as needed based on natural and contaminant oxygen demand calculations.

  No new wells are needed for EAD substrate injections because they would be performed using a direct push probe rig. For cost estimation purposes, EAD is assumed to require one injection event per year for 5 years.

  The institutional and engineering controls and long- and short-term monitoring described above for Alternative 1 also apply to Alternative 2b. Proposed groundwater monitoring specific to the ERD and EAD remedy in RA 5 includes semiannual groundwater monitoring in 14 new injection wells and 9 existing RA 5 property boundary monitoring wells with semiannual reporting. The number and locations of the new injection and monitoring wells are dependent on results of the initial pre-design soil and groundwater sampling event for RA 5.

- **Excavation with Off-Site Disposal.** Excavation of impacted soil exceedance areas within RA 5 would be performed to meet FMCLs for MoRPH and PCBs constituents. The depth of the excavation is anticipated to range from 0.5 to 5.5 feet bgs, resulting in a volume of approximately 70 cy. The volume of removed soil could increase based on the confirmation soil sampling results.

Soil in RA 5 exceeds the leaching SLs for cVOCs and DRPH and potentially impact groundwater in exceedance areas cVOC-1 and DRPH-2, respectively. Excavation of either of these soil areas would be performed if groundwater cleanup levels cannot be achieved by ERD and/or EAD. Excavation to leaching SLs would result in an additional volume of approximately 630 cy.

In addition to the remedial technologies applicable to cVOCs, Adaptive Management processes are reserved to address the potential need for groundwater corrective measures for inorganic and organic COCs:

- **Adaptive Management for Inorganics in Groundwater.** The potential for groundwater treatment technology has been retained for the inorganic constituents represented by exceedance areas Arsenic-1, Arsenic-14, and CuZn-1. These inorganic exceedance areas are well delineated within Plant 2 and have not been detected at the POC, but they are present at Plant 2's southern property boundary. Ongoing groundwater monitoring data considered through the Adaptive Management process will indicate if any specific corrective action for one or more of these exceedance areas is warranted.

  Where Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations. The Adaptive Management process for inorganic COCs is shown graphically on Figure 6-12.

- **Adaptive Management for Organics in Groundwater.** The potential for groundwater treatment technology has been retained for the organic constituents represented by exceedance areas cVOC-1, cVOC-2, BTEX-1, BTEX-2, DRPH-1, and DRPH-2. These exceedance areas are generally well delineated, within Plant 2 and have not been detected at the POC, but they are present at Plant 2's southern property boundary.

  Implementation of the proposed corrective measure is expected to achieve FMCLs for these exceedance areas; however, there might be some POC locations that do not achieve or consistently maintain FMCLs over time for organic COCs. A suitable corrective action technology will only be considered if groundwater monitoring data indicate that further consideration of corrective action for one or more of these exceedance areas is warranted.

  Where Adaptive Management for organics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective technology determinations. The Adaptive Management process for organic COCs is shown graphically on Figure 6-13.

6.10.2 Remedial Alternatives for RA 5

Applicable remedial technologies for soil and groundwater in RA 5 have been assembled into remedial alternatives that are based on media, constituent, and location-specific considerations. In addition to impacted groundwater, the remedial alternatives consider the presence of TCE, VC, benzene, and ethylbenzene in soil at concentrations greater than the leaching SLs as a potential source to groundwater. Assembled groups of remedial technologies are identified as numbered alternatives that are described below and are summarized in Table 6-5B.

With the exception of Alternative 1, the changed soil and groundwater conditions in RA 5 require the performance of an initial pre-design soil and groundwater sampling event using a direct push probe rig to establish the current extent and concentrations of COCs in the RA 5 exceedance areas. Necessary adjustments to the scope and design of the selected remedial alternative would be made based on results of this sampling event.

Alternative 1 – Corrective Action Not Required with Controls: This remedial alternative is applicable for areas with no active measures, but where the following remedial technologies are used:

- No Corrective Action needed
- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics

Alternative 1 requires no additional active corrective actions for soil as long as the buildings and pavement remain in place, if results from the initial soil and groundwater sampling event indicate that COCs in soil are no longer sources to groundwater. However, Alternative 1 would utilize remedial technologies that are currently in place, including Engineering Controls and Institutional Controls. This alternative depends on the success of the naturally occurring bio/chemical degradation processes to remediate the organic constituents present in RA 5. Alternative 1 does not include corrective actions for groundwater because groundwater data do not indicate that contamination from this RA reaches the POC. The protectiveness of this alternative would be evaluated with short- and long-term groundwater monitoring in the shoreline monitoring wells. This alternative serves as the baseline for comparison to other alternatives.

Alternative 2 – ERD: This remedial alternative adds ERD to Alternative 1 and would be expected to decrease the restoration timeframe relative to Alternative 1.

The proposed ERD remedy assumes annual nutrient injections in the eight injection wells over a period of 5 years to maintain geochemical conditions favorable for ERD. Alternative 2 also includes semiannual groundwater sampling for an assumed 5 years in 14 new injection wells and 9 existing RA 5 property boundary monitoring wells: PL2-151A, PL2-156A, PL2-601A, PL2-601B, PL2-602A, PL2-602B, PL2-603A, PL2-603B, and PL2-112A (assuming no additional monitoring wells are needed based on pre-design data). ERD monitoring includes semiannual reporting (assumed for 5 years).

Alternative 2 includes the following remedial technologies:

- ERD for cVOCs
- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics

In addition to long- and short-term groundwater monitoring performed in the property boundary monitoring wells within RA 5, this alternative would likely require additional monitoring in existing and/or new wells to evaluate the performance of the ERD remedial technology.

Alternative 2a – ERD and Excavation with Off-Site Disposal: This remedial alternative is the same as Alternative 2, but adds excavation of vadose-zone soil in the BTEX and petroleum hydrocarbon exceedance areas BTEX-1, BTEX-2, DRPH-1, and DRPH-2. The proposed excavation work associated with this alternative is solely intended to address BTEX and petroleum hydrocarbon exceedance areas because the ERD remedy alone would not remediate those exceedance areas. No further excavation is proposed for cVOCs.

Alternative 2a would be expected to decrease the restoration timeframe relative to Alternative 2 and includes the following remedial technologies:

- Excavation with Off-Site Disposal
- ERD for cVOCs
- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics

In addition to long- and short-term groundwater monitoring performed in the property boundary monitoring wells within RA 5, this alternative would likely require additional monitoring in existing and/or new wells to evaluate the performance of the ERD remedial technology. The institutional and engineering controls and long-term and short-term monitoring described above for Alternative 1 also apply to Alternative 2a. Proposed groundwater monitoring specific to the ERD remedy in RA 5 includes semiannual groundwater monitoring in 14 new injection wells and 9 existing RA 5 property boundary monitoring wells with semiannual reporting. The number and locations of the new injection and monitoring wells are dependent on results of the initial soil and groundwater sampling event for RA 5.

Alternative 2b – ERD followed by EAD: This remedial alternative adds EAD to Alternative 2 remediation of BTEX and petroleum hydrocarbon exceedance areas in RA 5. Because ERD and EAD are incompatible technologies they would be implemented sequentially with ERD performed first, followed by EAD upon completion of ERD.

This combination of remedial technologies would be expected to decrease the restoration timeframe relative to Alternative 2 and includes the following remedial technologies:

- ERD for cVOCs
- EAD for BTEX
- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics

In addition to long- and short-term groundwater monitoring performed in the property boundary monitoring wells within RA 5, this alternative will include sampling of additional monitoring wells to evaluate the performance of the ERD and EAD remedial technologies. The institutional and engineering controls and long- and short-term monitoring described above for Alternative 1 also apply to Alternative 2b. Proposed groundwater monitoring specific to the ERD and EAD remedy in RA 5 includes semiannual groundwater monitoring in 14 new injection wells and 9 existing RA 5 property boundary monitoring wells with semiannual reporting. The number and locations of the new injection and monitoring wells are dependent on results of the initial soil and groundwater sampling event for RA 5.

Alternative 2c – ERD, EAD, and Excavation with Off-Site Disposal: The ERD and EAD portions of this alternative are the same as Alternative 2b above with the additional scope of work of excavation with off-site disposal of vadose-zone soil with the greatest concentrations of cVOC constituents based on DGI data.

This combination of remedial technologies would be expected to decrease the restoration timeframe relative to Alternative 2, 2a, and 2b. The combination of technologies is as follows:

- Excavation with Off-Site Disposal
- ERD for cVOCs
- EAD for BTEX
- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics

In addition to long- and short-term groundwater monitoring performed in the property boundary monitoring wells within RA 5, this alternative would likely require additional monitoring in existing and/or new wells to evaluate the performance of the ERD and EAD remedial technologies. The institutional and engineering controls and long- and short-term monitoring described above for Alternative 1 also apply to Alternative 2c. Proposed groundwater monitoring specific to the ERD, EAD, and excavation with off-site disposal in RA 5 includes semiannual groundwater monitoring in 14 new injection wells and 9 existing property boundary monitoring wells with semiannual reporting. The number and locations of the new injection and monitoring wells are dependent on results of the initial soil and groundwater sampling event for RA 5.

Alternative AM-1 – Adaptive Management for Inorganics in Groundwater: The Adaptive Management process for inorganics might be combined with any of the previously described alternatives as noted in Table 6-5A. Adaptive Management would be considered if future shoreline monitoring data indicate that inorganic COCs are present at concentrations exceeding FMCLs in groundwater at the POC as described in Section 6.3.8 and Figure 6-12. Where Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations.

Alternative AM-2 – Adaptive Management for Organics in Groundwater: The Adaptive Management process for organics might be combined with any of the previously described alternatives as noted in Table 6-5A. Adaptive Management would be considered if future shoreline monitoring data indicate that organic COCs are present at concentrations exceeding FMCLs in groundwater at the POC as described in Section 6.3.8 and Figure 6-13. Where Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations.

6.10.3 RA 5 – Remedial Alternative Descriptions and Total Net Benefit Ratings

The following sections summarize each of the remedial alternatives that are evaluated for RA 5 – South Yard Area. A summary table rating how effectively the proposed remedial alternatives meet RCRA Alternative Evaluation Standards and other factors is presented as Table 6-5C. The technical rationale for the RA 5 remedial alternatives ratings are presented in Attachment S6C.

Alternative 1: Corrective Action Not Required with Controls – Alternative 1 is based on establishing an environmental covenant for the site and utilizing existing engineering controls including security fencing, pavement, and stormwater management to control exposure pathways to the environment. Alternative 1 also includes short- and long-term groundwater monitoring at the POC and the property boundary (i.e., shoreline and property boundary monitoring). The total net benefit rating for Alternative 1 is 21, as noted in Table 6-5C.

Alternative 2: ERD – ERD includes all the elements of Alternative 1 plus the introduction of nutrients into groundwater via 10 new 4-inch-diameter, A-Level injection wells and four new 4-inch-diameter, B-Level injection wells to enhance reducing geochemical conditions and increase the rate of reductive dechlorination of A-Level exceedance area cVOC-1 and B-Level exceedance area cVOC-2. The total net benefit rating for Alternative 2 is 24, as noted in Table 6-5C.

Alternative 2a: ERD with Excavation and Off-Site Disposal – The ERD portion of this alternative is the same as Alternative 2 with excavation and off-site disposal of vadose-zone soil with concentrations that exceed soil FMCLs and leaching SLs contributing to groundwater impacts. Excavation of the areas with the greatest concentrations of petroleum hydrocarbons would support groundwater corrective actions for benzene and petroleum hydrocarbon exceedance areas BTEX-1, BTEX-2, DRPH-1, and DRPH-2. The total net benefit rating for Alternative 2a is 25, as noted in Table 6-5C.

Alternative 2b: ERD followed by EAD – The ERD portion of Alternative 2b is the same as Alternative 2 above with the additional scope of work associated with EAD to remediate RA 5 groundwater benzene and petroleum hydrocarbon exceedance areas BTEX-1, BTEX-2, DRPH-1, and DRPH-2. The total net benefit rating for Alternative 2b is 24, as noted in Table 6-5C.

Alternative 2c: ERD, EAD, with Excavation and Off-Site Disposal – The ERD and EAD portions of this alternative are the same as Alternative 2b above with the addition of excavation with off-site disposal of vadose-zone soil with the greatest concentrations of cVOC constituents based on DGI data. The total net benefit rating for Alternative 2c is 23, as noted in Table 6-5C.

Alternative AM-1: Adaptive Management for Inorganics in Groundwater – If the Adaptive Management process for inorganics is warranted, Boeing will work in coordination with and seek

approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations as shown in Figure 6-12. The appropriate strategy resulting from this process cannot be known or evaluated at this time.

Alternative AM-2: Adaptive Management for Organics in Groundwater – If the Adaptive Management process for organics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations as shown in Figure 6-13. The appropriate strategy resulting from this process cannot be known or evaluated at this time.

6.10.4 RA 5 – Recommended Remedial Alternative

As summarized in Table 6-5C, the remedial alternative with the greatest total net benefit is Alternative 2a, ERD with Excavation and Off-Site Disposal, with a result of 25 out of a possible 30. Previous implementation of ERD IMs inside of the 2-66 Sheetpile, at OA 12, and at other locations at Plant 2 has demonstrated that ERD is effective and highly implementable. This remedial alternative adds excavation of vadose zone soil in the BTEX and petroleum hydrocarbon exceedance areas BTEX-1, BTEX-2, DRPH-1, and DRPH-2 to remove potential sources. In addition, this alternative would remove soils that exceed soil FMCLs MoRPH and PCBs. The depth of the excavation is anticipated to range from 0.5 to 5.5 feet bgs, resulting in a volume of approximately 70 cy. The volume of removed soil could increase based on the confirmation soil sampling results. The estimated cost for implementation of Alternative 2a is not prohibitive and the destruction of the cVOCs provides substantial benefit. Therefore, Alternative 2a is the recommended remedial alternative for RA 5.

A conceptual design layout for the injection well network in RA 5 is presented in Figure 6-7B. As noted in the preceding section, the number and locations of the new injection and monitoring wells are dependent on results of the initial pre-design soil and groundwater sampling event for RA 5.

Alternative 2a is designed to remediate the cVOC, BTEX, and petroleum hydrocarbon groundwater exceedance areas present in RA 5 but it does not directly remediate the inorganic exceedance areas in RA 5. Successful completion of Alternative 2a is expected to allow groundwater to return to natural geochemical conditions, which should reduce inorganic concentrations within approximately 5 years. If future monitoring data indicate inorganic or organic FMCL exceedances in groundwater at the POC, then Alternatives AM-1 or AM-2, respectively, would be pursued in coordination with EPA.

Supporting technical discussions and rationale for the rating assigned to each of the RCRA Alternative Evaluation Standards are presented in Attachment S6C.

6.11 RA 6 – OA 18 Area

RA 6 located within the paved industrial area surrounding RCRA Unit OA 18, Building 2-40 East Parking Lot Area (Figure 6-8A). During the 1940s this area was used as an airplane tow path between Plant 2 and KCIA. Constituents of interest identified during the RFI were VOCs, cPAHs, naphthalene, PCBs, TPH, and metals. The RFI identified a cPAH-impacted area approximately 120 feet wide, with a dark, black-stained fill observed in soil borings from 2 to 6 feet bgs.

RA 6 contains groundwater with concentrations of cVOCs (cDCE and VC) and copper are greater than their respective FMCLs. The cVOC exceedance area, cVOC-7, is the EMF Plume, which is undergoing corrective actions, monitoring, and reporting under a separate USEPA-administered program. These probe data are likely anomalous resulting from disturbed, turbid groundwater samples common to probes. The respective exceedance areas for these constituents are identified in Table 6-6A and presented in the various figures identified below. Pending COCs BEHP, cadmium, and free cyanide were also identified in this RA. The 1.7 μg/L BEHP detection in data from PL2-440B is anomalous because BEHP was not detected in the sample from corresponding well PL2-440A, nor from any sample collected before or after 2008.

Exceedance Area	Associated Figures
cVOC-7 (EMF Plume)	Figure 4-2D and 6-8A
CuZn-22	Figures 4-5D and 6-8A
Cyanide-3	Figures 4-6D and 6-8A

Groundwater exceedance areas within RA 6 are well delineated, stable or shrinking relative to historical conditions and are located far upgradient from the POC. Long-term monitoring at the shoreline monitoring well network 6.12 will ensure groundwater exceedances area will not extend beyond the POC. However, soil remedies proposed for this RA would likely benefit groundwater conditions with the removal of mass and the added protection of an overlying pavement.

Twelve soil sample locations in OA 18 exceed the FMCLs for cPAH, naphthalene, free cyanide, DRPH, and MoRPH between 1 and 7 feet bgs (Figure 6-8A and Table 6-6A). Concentrations of

RA 6 – OA 18 Area

Key Features

OA 18 Area is a paved parking lot in front of the former Building 2-40 within the paved industrial area.

COCs Driving Remedy Selection

Groundwater: Groundwater is not the driver for RA 6 remedies.

Soil: cPAH, naphthalene, free cyanide, DRPH, and MoRPH

Considerations Affecting Remedy Selection: COCs in soil above FMCLs are located in shallow surface soils from 1 to 7 feet bgs.

Cyanide in soil above the leaching SL is limited to one location at 7 feet bgs.

Metal and BEHP groundwater exceedance areas are suspected to be comprised of false positive results on the basis of data collection or analysis methods.

RCRA Units Associated with Current RA Corrective Action(s)

OA 18

POC Monitoring Wells (downgradient of RA 6)

PL2-619A, PL2-619B

PL2-620A, PL2-620B

cPAH, naphthalene, and GRPH exceeding the leaching SLs were identified at depths between 3 and 10 feet below ground surface, as shown in Figure 6-8A.

Figure 6-8B presents the proposed remedial alternative for RA 6 to support the discussion in the sections that follow. A CSM cross section for RA 6 depicting hydrogeologic conditions based on data through January 2013 is presented in Figure 6-8C. The east-west cross section alignment for the RA 6 CSM is shown on Figure 6-8B.

6.11.1 Applicable Remedial Technologies for RA 6

Remedial alternatives for RA 6 would address the presence of cPAH, naphthalene, free cyanide, DRPH, and MoRPH that exceed soil and/or groundwater FMCLs associated with OA 18. Constituents that have been detected in soil or groundwater at concentrations greater than their applicable FMCLs in RA 6 are presented in Table 6-6A and Figure 6-8. Table 6-6A identifies the technologies that were considered to address the COCs present in RA 6. Applicable technologies are described in the text that follows:

- **Engineering Controls.** The OA 18 asphalt parking lot currently serves as a physical barrier to direct contact with soil that exceeds FMCLs at the 12 locations seen in Figure 6-8A. Public exposure would be prevented by physical barriers in the form of fencing and Boeing security.
- **Institutional Controls.** Institutional controls in the form of an environmental covenant would require RA 6 to remain paved or covered by buildings. These controls would be consistent with the technology description presented in Section 6.3 and Attachment S5A.
- **Long-Term Groundwater Monitoring.** Long-term groundwater monitoring is not directly applicable to groundwater exceedance areas or to FMCL exceedances in soil; however, A- and B-Level shoreline monitoring wells PL2-619A, PL2-619B, PL2-620A, PL2-620B, PL2-621A, and PL2-621B would be used to monitor groundwater at the POC, which is approximately 950 feet downgradient from RA 6. These wells would be monitored semiannually as part of the shoreline monitoring program. Upgradient monitoring wells PL2-440A, PL2-440B, and PL2-440C would initially be monitored on a proposed schedule described in the CMI Work Plan for RA 6 and would revert to an annual sampling frequency for PL2-440A and PL2-440B and every 5 years for PL2-440C as described in Attachment S6A when corrective action goals outlined in the CMI Work Plan for RA 6 are met.
- **Excavation with Off-Site Disposal.** Excavation of impacted soil exceedance areas within RA 6 would be performed to meet FMCLs for cPAH, free cyanide, naphthalene, DRPH, and MoRPH. This action is expected to improve groundwater quality in exceedance area Cyanide-3. The depth of the excavation would be determined at the time the work is completed based on soil sampling results and/or confirmation sampling. The depth of the excavation is anticipated to range from 1 to 7 feet bgs, resulting in a volume of approximately 2,700 cy.

In addition to the remedial technologies applicable to cVOCs, the Adaptive Management process is reserved to address the potential need for groundwater corrective measures for organics:

- **Adaptive Management for Organics in Groundwater.** The potential for groundwater treatment technology has been retained for the organic constituents represented by

exceedance area cVOC-7. This exceedance area is the EMF Plume, which is well delineated and is undergoing corrective measures under a separate program administered by USEPA.

Implementation of the proposed corrective measures is expected to achieve FMCLs for this exceedance area; however, there might be some POC locations that do not achieve or consistently maintain FMCLs over time for organic COCs. A suitable corrective action technology will only be considered if groundwater monitoring data indicate that further consideration of corrective action for this exceedance area is warranted.

Where Adaptive Management for organics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective technology determinations. The Adaptive Management process for organic COCs is shown graphically on Figure 6-13.

6.11.2 Remedial Alternatives for RA 6

Applicable remedial technologies for soil and groundwater in RA 6 have been assembled into remedial alternatives that are based on media, constituent, and location-specific considerations. In addition to impacted soil and groundwater, the remedial alternatives consider the presence of free cyanide in soil at concentrations greater than the leaching SLs as a potential source to groundwater. Assembled groups of remedial technologies are identified below as numbered alternatives and are summarized in Table 6-6B. The alternatives for RA 6 are:

Alternative 1 – Corrective Action Not Required with Controls: This remedial alternative is applicable for areas with no active measures, but where the following remedial technologies are used:

- No Corrective Action needed for soil and groundwater
- Institutional Controls
- Engineering Controls
- Long-term Monitoring

Alternative 1 requires no additional active corrective actions for soil and groundwater. However, Alternative 1 would utilize remedial technologies that are currently in place, which includes Engineering Controls and Institutional Controls. The protectiveness of this alternative would be evaluated with long-term groundwater monitoring in the shoreline monitoring wells and upgradient monitoring wells. This alternative serves as the baseline for comparison to other alternatives.

Long-term groundwater monitoring of groundwater exceedance areas or potential soil source areas will not take place within RA 6; however, long-term groundwater monitoring is still considered an applicable technology for this RA because A- and B-Level shoreline monitoring wells would be used to monitor groundwater at the POC downgradient from RA 6.

Alternative 2 – Excavation with Off-Site Disposal: This remedial alternative adds excavation with off-site disposal to Alternative 1 and would be expected remove all soil exceeding FMCLs and decrease the restoration timeframe for groundwater relative to Alternative 1. Alternative 2 includes the following remedial technologies:

- Excavation with Off-Site Disposal
- Institutional Controls
- Engineering Controls
- Long-term Monitoring

Alternative AM-2 – Adaptive Management for Organics in Groundwater: The Adaptive Management process for organics might be combined with any of the previously described alternatives as noted in Table 6-6A. Adaptive Management would be considered if future shoreline monitoring data indicate that organic COCs are present at concentrations exceeding FMCLs in groundwater at the POC as described in Section 6.3.8 and Figure 6-13. Where Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations.

6.11.3 RA 6 – Remedial Alternative Descriptions and Total Net Benefit Ratings

In accordance with the evaluation process described in Section 6.5, Table 6-6C presents a summary of how effectively the proposed remedial alternatives meet the RCRA criteria. The following summarizes the RA 6 remedial alternatives and provides the net benefit score from Table 6-6C. Evaluation of RA 6 remedial alternatives is provided in detail in Attachment S6C, which includes complete descriptions of the proposed elements and scopes of work for the remedial alternatives.

Alternative 1: Corrective Action Not Required with Controls – Alternative 1 is based on establishing an environmental covenant for the site and utilizing existing engineering controls including security fencing, the OA 18 asphalt parking lot, and stormwater management to control exposure pathways to the environment. The total net benefit rating for Alternative 1 is 21, as noted in Table 6-6C.

Alternative 2: Excavation with Off-Site Disposal – Alternative 2 includes all the elements of Alternative 1 plus excavation with off-site disposal of impacted soil exceedance areas within RA 6 to meet proposed industrial soil FMCLs for cPAH, naphthalene, free cyanide, DRPH, and MoRPH. In addition, excavation would remove soil with concentrations of free cyanide exceeding the leaching SL and potentially remediate Cyanide-3. The volume of soil that would be excavated in RA 6 is estimated to be 2,700 cy.

A- and B-Level shoreline monitoring wells PL2-619A, PL2-619B, PL2-620A, PL2-620B, PL2-621A, and PL2-621B would be used to monitor groundwater at the POC downgradient from RA 6 on a semiannual schedule as part of the shoreline monitoring program as described in Attachment S6A. Upgradient wells PL2-440A, PL2-440B, and PL2-440C would initially be monitored on a proposed schedule described in the CMI Work Plan. The total net benefit rating for Alternative 2 is 23, as noted in Table 6-6C.

Alternative AM-2: Adaptive Management for Organics in Groundwater – If the Adaptive Management process for organics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations as shown in Figure 6-13. The appropriate strategy resulting from this process cannot be known or evaluated at this time.

6.11.4 RA 6 – Recommended Remedial Alternative

As noted in Table 6-6C, the remedial alternative with the greatest total net benefit is Alternative 2, Excavation with Off-Site Disposal, with a result of 23 out of a possible 30. Previous IMs at Plant 2 have demonstrated that this technology is effective and highly implementable. Comparatively, cost for implementation of this alternative is not prohibitive and excavation of contaminated soil provides substantial benefit. Alternative 2, Excavation with Off-Site Disposal and Long-term Monitoring, is the recommended remedial alternative for RA 6.

Alternative 2 is not designed to directly remediate the copper groundwater exceedance areas present in RA 6, but would likely benefit those groundwater exceedance areas. Successful completion of Alternative 2 is anticipated to allow groundwater to return to natural geochemical conditions, which should reduce metals concentrations within approximately 5 years. If future monitoring data indicate organic FMCL exceedances in groundwater at the POC, then Alternative AM-2 would be pursued in coordination with USEPA.

6.12 RA 7 – Unpaved Shoreline Area

South of the 16th Avenue South Bridge, RA 7 consists of the unpaved shoreline area located west of the paved industrial area and adjacent to the Habitat Area (Figure 6-9A1). North of the bridge, RA 7 consists of the unpaved shoreline area adjacent to the Duwamish Waterway, Habitat Area, and Slip 4 (Figure 6-9A2). From 2010 to 2012, as part of redevelopment, lined stormwater bioswales and treatment vaults were installed in the unpaved shoreline area as part of the new stormwater system. The area includes shoreline monitoring wells PL2-612AR, PL2-616A, PL2-617A, PL2-618A, PL2-619A, PL2-619B, PL2-620A, and PL2-620B, which were installed after the DSOA and habitat work was completed. Some of the RA 7 wells listed are included in other RAs.

Historically, RA 7 contains groundwater with concentrations of COCs cVOCs (cDCE, TCE, and VC), zinc and PCBs that are greater than their respective FMCLs. Some of the exceedances are based on suspect data discussed in Section 2.0 and presented in Table 2-1. Additionally, several groundwater exceedance areas are in the portion of the shoreline that were remediated in 2013 as part of the DSOA and SW Bank Corrective Measure and associated habitat areas. RA 7 also contains groundwater with concentrations of MoRPH greater than its TMCL. The respective exceedance areas for these constituents are identified in Table 6-7A and presented in the various figures identified below. Pending COCs BEHP and free cyanide were also historically identified in this RA at concentrations worthy of further evaluation under the short-term groundwater monitoring process outlined in Section 6.3.5.

TCE, DRPH, GRPH, and MoRPH were detected in RA 7 at one discrete soil sample (P2IM-SM-05) at 11 feet bgs at concentrations greater than the applicable FMCLs (Table 6-7A and Figures 6-9A1 and 6-9A2).

RA 7 – Unpaved Shoreline Area

Key Features

The unpaved shoreline area is located west of the paved industrial area and adjacent to/east of the Duwamish Waterway. Soil FMCLs are based on unrestricted (residential) land use, rather than industrial land use.

COCs Driving Remedy Selection

Groundwater: cVOCs (TCE, cDCE, and VC)

Soil: TCE, GRPH, DRPH, and MoRPH

Considerations Affecting Remedy Selection: TCE, DRPH, GRPH, and MoRPH present in soil above the FMCLs are limited to one location.

Metal and BEHP groundwater exceedance areas are suspected to be comprised of false positive results on the basis of data collection or analysis methods. MoRPH results need to be quantified as specific constituents with FMCLs in future sampling.

Tunnels with PCB-impacted concrete are upgradient of this RA, as shown in Figure 3.4.

RCRA Units Associated with Current RA Corrective Action(s)

OA 1, OA 14, OA 17.8, SWMU 2-41.30, SWMU 2-41.31, SWMU 2-41.33, SWMU 2-41.34, SWMU 2-41.36, SWMU 2-01.1

POC Monitoring Wells

PL2-616A, PL2-617A, PL2-618A, PL2-619A, PL2-619B, PL2-620A, PL2-620B, PL2-612AR

Concentrations of PCBs exceeding the leaching SLs were identified in four soil samples between 10 and 11 feet bgs and cDCE in one soil sample at a depth of 11 feet bgs (exceedance locations and concentrations are presented in Figures 6-9A1 and 6-9A2). These locations are in the same general area as the PCB detection in groundwater using unfiltered direct push-probe results.

Concrete with residual PCB contamination was reused on site as discussed in Section 3.2.2. This area is immediately upgradient of the south portion of RA 7.

RA 7 contains habitat areas and is adjacent to DSOA where corrective measures have been completed, a status column is included to identify what data needs to be collected to confirm success of those actions at removing prior contamination and updating groundwater data set.

Constituent Exceedance Area	**Associated Figures**	**Status**
cVOC-8	Figures 4-2D and 6-9A1	A-Level exceedance at PL2-618A; if still present, will be handled as part of RA 4 corrective action.
cVOC-9	Figures 4-2D and 6-9A1	C-Level exceedance at EMF compliance well PL2-435C; being handled as part of EMF project.
cVOC-10	Figures 4-2D and 6-9A1	A-Level exceedances for probes in area south of RA 3; being handled as part of EMF project.
Arsenic-3	Figures 4-4D and 6-9A1	Shoreline monitoring well PL2-618A will confirm FMCL compliance.
CuZn-8	Figures 4-5D and 6-9A1	B-Level zinc based solely on probe data.
CuZn-9	Figures 4-5D and 6-9A1	C-Level zinc based solely on probe data.
CuZn-18	Figures 4-5E and 6-9A2	Located in North Area; suspect C-Level probe data for Cu in saline groundwater. See Table 2-1.
CuZn-19	Figures 4-5E and 6-9A2	Located in North Area; suspect B-Level probe data for Zn in saline groundwater. See Table 2-1.
Cyanide-4, Cyanide-5, and Cyanide-6	Figures 4-6D and 6-9A1	Data will be collected for analytical method compatible with free cyanide FMCL; see Table 2-1.
DRPH-6	Figures 4-7D and 6-9A1	Shallow contamination, mostly removed during construction of swales in 2012. Shoreline monitoring well PL2-619A will confirm FMCL compliance.

Figure 6-9B presents the proposed remedial alternative for RA 7 to support the discussion in the sections that follow. CSM cross sections for RA 7 depicting hydrogeologic conditions based on data through January 2013 are presented in Figure 6-9C1 and Figure 6-9C2 for the south and north portions of RA 7, respectively. The north-south cross section alignment for the RA 7 CSM is shown on Figure 6-9B. Figure 6-9D1 and Figure 6-9D2 depict the south and north RA 7 CSMs, respectively, adjusted with data through December 2016, where applicable.

6.12.1 Applicable Remedial Technologies for RA 7

Remedial alternatives for RA 7 were designed to address the presence of cVOCs, DRPH, GRPH, MoRPH, and PCBs and specific inorganics (arsenic, zinc, and free cyanide) that exceed soil and/or groundwater FMCLs. Constituents detected in soil or groundwater at concentrations greater than their applicable FMCLs in RA 7 are presented in Table 6-7A and Figures 6-9A1 and 6-9A2. Table 6-7A identifies the technologies that were considered to address the COCs present in RA 7. Applicable technologies are described in the text that follows:

- **Engineering Controls.** No engineering controls are planned. Access is difficult and requires either access through Boeing property or climbing the steep bank from the waterway at extremely low tides. Cleanup levels for direct contact are based on unrestricted (residential) land use.
- **Institutional Controls.** Institutional controls in the form of environmental covenants would identify what physical activity is allowed in the unpaved shoreline and would discourage public access. These controls would be consistent with the technology descriptions presented in Section 6.3 and Attachment S5A. Primarily these are designed to protect the stormwater infrastructure and the adjacent habitat areas.
- **Long-Term Groundwater Monitoring.** Existing shoreline wells PL2-612AR, PL2-616A, PL2-617A, PL2-618A, PL2-619A, PL2-619B, PL2-620A, and PL2-620B would be used to monitor groundwater at the POC for RA 7. Shoreline wells would be monitored on a semiannual schedule as part of the shoreline monitoring program as described in Attachment S6A.

  Because there are no surface water standards for TPH, it is regulated in groundwater using the mobile constituents BTEX and naphthalene as discussed in Section 2.0. The MoRPH detection in groundwater in an A-Level direct-push-probe is being treated as a groundwater FMCL exceedance. The shoreline monitoring well PL2-619A, located within a few feet of the historical direct-push-probe detection would be used to determine whether groundwater is in compliance for the TPH constituents, BTEX and naphthalene.
- **Short-Term Groundwater Monitoring.** Boeing proposes to sample wells PL2-619A and PL2-619B for free cyanide over four semiannual shoreline monitoring events (Table 2-1 and Attachment S2B). Monitoring well PL2-615 in RA 4 will also be used to support free cyanide monitoring in association with RA 7. If there are no FMCL exceedances for free cyanide during the four semiannual events at these three wells, Boeing will evaluate the data without the use of statistics to determine if continued free cyanide monitoring is warranted. If there are exceedances of the FMCL, those wells with exceedances will be sampled for free cyanide for a total of eight semiannual events. Boeing will evaluate the data using the 95% UCL statistical evaluation to determine if continued free cyanide monitoring is warranted.

Boeing proposes to sample well PL2-612AR for arsenic over four semiannual shoreline monitoring events (Table 2-1 and Attachment S2B). Well PL2-612AR, located along Slip 4, is being analyzed for total arsenic for four semiannual shoreline monitoring events to determine if elevated arsenic concentrations noted in two upgradient direct push probes during the DGI were anomalous values or representative of groundwater conditions. If there are no FMCL exceedances for total arsenic during the four events, the data from PL2-612AR will be evaluated without the use of statistics to determine if continued total arsenic monitoring is warranted at PL2-612AR. If there are exceedances of the total arsenic FMCL, PL2-612AR will be sampled for a total of eight semiannual events. Boeing will evaluate the data using the 95% UCL statistical evaluation to determine if continued total arsenic monitoring is warranted.

Crushed concrete used as backfill for demolished tunnels during site redevelopment contained low level PCBs (<10 mg/kg) (Section 3.1). This crushed concrete is present in RA 3, RA 4, and RA 8. No crushed concrete was placed in the unpaved shoreline area (RA 7). However the shoreline monitoring wells in the south portion of RA 7 are downgradient of the backfilled tunnels.

Although the crushed concrete was placed above the groundwater table, Boeing has sampled PL2-617A, PL2-618A, PL2-619A, and PL2-620A for PCBs for four events, ending with the March 2017 Shoreline Monitoring event. Because concentrations of PCBs in these shoreline wells were less than the PQL and MDL during four consecutive monitoring events, Boeing discontinued sampling at these shoreline wells.

In the future, USEPA may require sampling for PCBs at wells where PCB sampling had previously been discontinued including PL2-617A, PL2-618A, PL2-619A, and PL2-620A in RA 7 (and PL2-621A in RA 3) as outlined below under “Adaptive Management for PCBs in Groundwater” Sections 6.8.3 and 6.13.3.

Shoreline well PL2-619A is in RA 7 and will be analyzed for BEHP for four semiannual shoreline monitoring events. If there are no FMCL exceedances for BEHP the data will be evaluated without the use of statistics. If there are FMCL exceedances PL2-619A will be monitored for BEHP for a total of eight events and those data will be evaluated using the 95% UCL statistical method to determine if continued BEHP monitoring is warranted. Boeing and USEPA will review the data and statistical evaluation to determine the appropriate course of action for continued monitoring and/or Adaptive Management following the process presented in Figure 6-13 for BEHP.

DGI probe data for inorganics in RA 7 are likely to be false positive analytical results. Boeing and USEPA will review the inorganics data from POC wells in RA 7 to determine the appropriate course of action using the Adaptive Management process for inorganics presented in Figure 6-12.

- **Bioventing.** An active bioventing system would be installed to provide oxygen to the subsurface at location P2IM-SM-05 and/or the location of a possible groundwater exceedance area, DRPH-6. The increased available oxygen is intended to stimulate the growth and activity of aerobic bacterial populations that are capable of degrading non-halogenated organic compounds. Bioventing of impacted soil in this area would be intended to bring soil and groundwater into compliance for TPH and/or its constituents.
- **Excavation with Off-Site Disposal.** Excavation of impacted soil exceedance areas within RA 7 would be performed to meet FMCLs for TCE, GRPH, DRPH, and MoRPH and the leaching SLs for DRPH potentially impacting DRPH-6. The depth of the excavation

would be determined at the time the work is completed based on soil sampling results and/or confirmation sampling. The depth of the excavation is anticipated to be 11 feet bgs, resulting in a volume of approximately 40 cy.

In addition to the remedial technologies applicable to cVOCs, Adaptive Management processes are reserved to address the potential need for groundwater corrective measures for inorganics, organics, and PCBs:

- **Adaptive Management for Inorganics in Groundwater.** The potential for groundwater treatment technology has been retained for the inorganic constituents represented by exceedance areas Arsenic-3 and Cyanide-4 through Cyanide-6. These exceedance areas are well-delineated and, in some cases, appear stable or decreasing. Although the data for each area vary, the inorganic constituents have generally not been detected at concentrations greater than FMCLs downgradient at the POC. Ongoing groundwater monitoring data considered through the Adaptive Management process will indicate if any specific corrective action for one or more of these exceedance areas is warranted.

  Where Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations. The Adaptive Management process for inorganic COCs is shown graphically on Figure 6-12.

- **Adaptive Management for Organics in Groundwater.** The potential for groundwater treatment technology has been retained for the organic constituents represented by exceedance areas cVOC-8 and cVOC-10. These exceedance areas are generally well delineated, and those constituents have occasionally been detected at concentrations greater than FMCLs at the POC in some RA 7 shoreline monitoring wells (e.g., PL2-616A and PL2-619A for TCE, and PL2-618A and PL2-620A for VC).

  Implementation of the proposed corrective measures is expected to achieve FMCLs for these exceedance areas; however, there might be some POC locations that do not achieve or consistently maintain FMCLs over time for organic COCs. A suitable corrective action technology will only be considered if groundwater monitoring data indicate that further consideration of corrective action for one or more of these exceedance areas is warranted.

  Where Adaptive Management for organics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective technology determinations. The Adaptive Management process for organic COCs is shown graphically on Figure 6-13.

- **Adaptive Management for PCBs in Groundwater.** The potential for groundwater treatment technology and additional groundwater monitoring has been retained for PCBs, as indicated above**,** PCBs have been analyzed for four semiannual events in samples from shoreline monitoring wells PL2-617A, PL2-618A, PL2-619A, and PL2-620A with no PCB detections using the current analytical method. Boeing temporarily discontinued analyzing for PCB Aroclors in groundwater at those locations.

  Boeing expects to conduct PCB analysis in groundwater using a high-sensitivity analytical method (e.g., USEPA Method 1668) to achieve a RL equal to or lower than the WQS, which is the TMCL for PCBs. Boeing will work with USEPA through an Adaptive Management process to apply the high-sensitivity PCB analysis method for this ongoing

groundwater monitoring, which may include specific requirements for data collection and analysis. As new PCB data collected under this method become available, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and response.

6.12.2 Remedial Alternatives for RA 7

Applicable remedial technologies for soil and groundwater in RA 7 have been assembled into remedial alternatives that are based on media, constituent, and location-specific considerations. In addition to impacted soil and groundwater, the remedial alternatives consider the presence of DRPH in soil greater than the industrial soil FMCL and leaching SLs as a potential source to groundwater. Assembled groups of remedial technologies are identified as numbered alternatives that are described below and are summarized in Table 6-7B.

Alternative 1 – Corrective Action Not Required with Controls: This remedial alternative is applicable for areas with no active measures, but where the following remedial technologies are used:

- No Corrective Action needed for soil or groundwater
- Institutional Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics, BEHP

Alternative 1 requires no additional active corrective actions for soil and groundwater. However, Alternative 1 would utilize remedial technologies that are currently in place, including Institutional Controls. The protectiveness of this alternative would be evaluated with short- and long-term groundwater monitoring in the shoreline monitoring wells. This alternative serves as the baseline for comparison to other alternatives.

Alternative 2 – Bioventing: This remedial alternative adds Bioventing to Alternative 1 and would be expected to decrease the restoration timeframe relative to Alternative 1. Alternative 2 includes the following remedial technologies:

- Bioventing
- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics and BEHP

Alternative 3 – Excavation with Off-Site Disposal: This remedial alternative adds Excavation with Off-Site Disposal to Alternative 1 and would be expected to decrease the restoration timeframe relative to Alternative 1. Alternative 3 includes the following remedial technologies:

- Excavation with Off-Site Disposal
- Institutional Controls

- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics, BEHP

Alternative AM-1 – Adaptive Management for Inorganics in Groundwater: The Adaptive Management process for inorganics might be combined with any of the previously described alternatives as noted in Table 6-7A. Adaptive Management would be considered if future shoreline monitoring data indicate that inorganic COCs are present at concentrations exceeding FMCLs in groundwater at the POC as described in Section 6.3.8 and Figure 6-12. Where Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations.

Alternative AM-2 – Adaptive Management for Organics in Groundwater: The Adaptive Management process for organics might be combined with any of the previously described alternatives as noted in Table 6-7A. Adaptive Management would be considered if future shoreline monitoring data indicate that organic COCs are present at concentrations exceeding FMCLs in groundwater at the POC as described in Section 6.3.8 and Figure 6-13. Where Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations.

Alternative AM-3 – Adaptive Management for PCBs in Groundwater: The Adaptive Management process for PCBs might be combined with any of the previously described alternatives as noted in Table 6-7A. Adaptive Management would be considered if future shoreline monitoring data indicate that PCBs are present at concentrations exceeding FMCLs in groundwater at the POC as described in Section 6.3.8. Where Adaptive Management for PCBs is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations.

6.12.3 RA 7 – Remedial Alternative Descriptions and Total Net Benefit Ratings

In accordance with the evaluation process described in Section 6.5, Table 6-7C presents a summary of how effectively the proposed remedial alternatives meet the RCRA criteria. The following summarizes the RA 7 remedial alternatives and provides the net benefit score from Table 6-7C. Evaluation of RA 7 remedial alternatives is provided in detail in Attachment S6C, which includes the technical rationale for ratings assigned to each of the remedial alternatives.

Alternative 1: Corrective Action Not Required with Controls – Alternative 1 is based on establishing an environmental covenant for the site and utilizing existing engineering controls including security fencing and stormwater management to control exposure pathways to the environment. Alternative 1 also includes short- and long-term groundwater monitoring at the POC (i.e., shoreline monitoring). The total net benefit rating for Alternative 1 is 21, as noted in Table 6-7C.

Alternative 2: Bioventing – Alternative 2 includes all the elements of Alternative 1 plus the installation of an active bioventing system to provide oxygen to the vadose-zone soil in the vicinity of P2IM-SM-05. The increased available oxygen is intended to stimulate the growth and activity of aerobic bacterial populations that are capable of degrading non-halogenated organic

compounds. Bioventing of impacted soil exceedance location P2IM-SM-05 would be performed to meet proposed shoreline soil FMCLs for GRPH, DRPH, and MoRPH constituents and leaching SLs for DRPH potentially remediating groundwater exceedance area DRPH-6. Implementation of bioventing would likely reduce concentrations of cVOCs and DRPH in groundwater exceedance areas. The total net benefit rating for Alternative 2 is 24, as noted in Table 6-7C.

Alternative 3: Excavation with Off-Site Disposal – Alternative 3 includes all the elements of Alternative 1 plus excavation of impacted soil exceedance areas within RA 7 to meet proposed shoreline soil FMCLs for TCE, GRPH, DRPH, and MoRPH and the leaching SLs for DRPH potentially impacting DRPH-6. Excavation would impact the current stormwater swale and potentially the stormwater treatment vault. Approximately 40 cy of soil would be excavated in RA 7. Disposal costs for the soil are based on an assumed "contained-out" designation. The total net benefit rating for Alternative 3 is 18, as noted in Table 6-7C.

Alternative AM-1: Adaptive Management for Inorganics in Groundwater – If the Adaptive Management process for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations as shown in Figure 6-12. The appropriate strategy resulting from this process cannot be known or evaluated at this time.

Alternative AM-2: Adaptive Management for Organics in Groundwater – If the Adaptive Management process for organics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations as shown in Figure 6-13. The appropriate strategy resulting from this process cannot be known or evaluated at this time.

Alternative AM-3: Adaptive Management for PCBs in Groundwater – If the Adaptive Management process for PCBs is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations. The appropriate strategy resulting from this process cannot be known or evaluated at this time.

6.12.4 RA 7 – Recommended Remedial Alternative

As noted in Table 6-7C, the remedial alternative with the greatest total net benefit is Alternative 2, Bioventing, with a result of 24 out of a possible 30. Previous soil IMs at Plant 2 have demonstrated that this technology is effective and highly implementable. Comparatively, cost for implementation of this alternative is not prohibitive and removal of TPH contamination provides substantial benefit. Alternative 2, Bioventing, is the recommended remedial alternative for RA 7.

Alternative 2 is not designed to directly remediate the zinc and free cyanide groundwater exceedance areas present in RA 7. However, performance of the corrective action to address DRPH and cVOCs changes in groundwater conditions will likely impact the inorganic groundwater exceedance areas. The successful completion of Alternative 2 is expected to allow groundwater to return to natural geochemical conditions, which is anticipated to reduce metals concentrations within approximately 5 years. If future monitoring data indicate inorganic or organic FMCL exceedances in groundwater at the POC, then Alternatives AM-1 or AM-2 respectively, would be implemented in coordination with USEPA.

Supporting technical discussions and rationale for the rating assigned to each of the RCRA Alternative Evaluation Standards are presented in Attachment S6C.

6.13 RA 8 – Paved Industrial Area

RA 8 encompasses the paved industrial area, which is primarily covered by concrete and asphalt paving, buildings, roadways, and small landscape areas (Figures 6-10A1, 6-10A2, and 6-10A3). Historically, manufacturing processes (machining aluminum alloy, steel alloy, and titanium alloy parts for airplanes) were performed in a number of the current and former (demolished) buildings at the facility.

RA 8 contains groundwater with concentrations of cVOCs (cDCE, TCE, and VC), benzene, ethylbenzene, naphthalene, arsenic, copper, zinc, and free cyanide that are greater than their respective FMCLs. Groundwater FMCL exceedance areas in RA 8 do not reach the POC and are well-delineated, and stable or shrinking. The respective exceedance areas for these constituents are identified in Table 6-8A rather than listed in this section, and are presented in the Section 4.0 and Section 6.0 figures.

Eight soil sample locations in the paved industrial area exceed the FMCL for arsenic, chromium (VI), free cyanide, cPAHs, and MoRPH between 2 and 11.5 feet bgs (locations and concentrations are presented in Figures 6-10A1, 6-10A2, and 6-10A3). Arsenic concentrations at location PL2-201B exceed the FMCL at a depth of 5 feet bgs; however, arsenic is not a soil COC (Table 2-10). Similarly, chromium (VI) concentrations exceed the soil FMCL at location SB-01023 at a depth of 6 feet bgs; however, chromium (VI) is not a Plant 2 soil COC (Table 2-10).

Concentrations of TCE, VC, arsenic, copper, cadmium, DRPH, GRPH, benzene, ethylbenzene (associated with GRPH), MoRPH, and PCBs exceeding the leaching SLs were identified between 7 and 11 feet bgs (exceedance locations and concentrations are presented in Figures 6-10A1, 6-10A2, and 6-10A3).

Figure 6-10B1 and 6-10B2 presents the proposed remedial alternative for RA 8 to support the discussion in the sections that follow. CSM cross sections for RA 8 are presented in Figures 6-10C1 and 6-10C2. The east-west cross section alignment for both figures is shown on Figure 6-10B1. Figure 6-10C1 depicts the RA 8 CSM based on data

RA 8 – Paved Industrial Area

Key Features

The Paved Industrial Area comprises the paved area of Plant 2.

The area has been subject of previous IMs and construction projects including 2010-2012 redevelopment.

COCs Driving Remedy Selection

Groundwater: cVOCs (cDCE, TCE, and VC), benzene, ethylbenzene, naphthalene, arsenic, copper, zinc, and free cyanide

Soil: arsenic, chromium (VI), free cyanide, cPAH, and MoRPH

Considerations Affecting Remedy Selection: Arsenic, free cyanide, chromium (VI), cPAH, and MoRPH present in soil above the FMCLs are limited to eight discrete locations.

Copper and PCBs in soil above the leaching SLs are a potential source to groundwater in this RA.

Groundwater exceedance areas are generally small, well delineated, stable or shrinking and do not reach the POC.

RCRA Units Associated with Current RA Corrective Action(s)

Multiple RCRA Units (see Figures 6-10A and 6-10B)

POC Monitoring Wells

PL2-612AR, PL2-613A (not installed), PL2-613B (not installed), PL2-614A, PL2-614B, PL2-615A, PL2-615B, PL2-616A, PL2-617A, PL2-618A, PL2-619A, PL2-619B, PL2-620A, PL2-620B, PL2-621A, PL2-621B, PL2-214A, PL2-214B, PL2-258A, PL2-258B, PL2-271A

through January 2013. Figure 6-10C2 depicts the RA 8 CSM adjusted with data through December 2016, where applicable.

6.13.1 Applicable Remedial Technologies for RA 8

Remedial alternatives for RA 8 were designed to address the presence of cVOCs, DRPH, GRPH, MoRPH, and PCBs and specific inorganics (arsenic, chromium (VI), copper, zinc, and free cyanide) that exceed soil and/or groundwater FMCLs. Exceedance areas in RA 8 are presented in Table 6-8A and Figures 6-10A1, 6-10A2, and 6-10A3. Table 6-8A identifies the technologies that were considered to address the COCs present in RA 8. Applicable technologies are described in the text that follows:

- **Engineering Controls.** The presence of the existing pavement and buildings in the paved industrial area serves as a physical barrier to direct contact with soil that exceeds the industrial FMCLs. These features minimize infiltration, which limits contaminant transport via the leaching pathway. RA 8 is physically accessible only to site workers. Public exposure would be prevented by physical barriers fencing and Boeing security.
- **Institutional Controls.** Institutional controls in the form of an environmental covenant would require the area to be covered by pavement or buildings. These controls would be consistent with the technology descriptions presented in Section 6.3 and Attachment S5A.
- **Long-Term Groundwater Monitoring.** Although most shoreline monitoring wells are not within the boundaries of RA 8, they serve as downgradient POC monitoring locations. Shoreline wells PL2-213A, PL2-214A, PL2-214B, PL2-227A, PL2-258A, PL2-258B, PL2-271A, PL2-612AR, PL2-614A, PL2-614B, PL2-615A, PL2-615B, PL2-616A, PL2-617A, PL2-618A, PL2-619A, PL2-619B, PL2-620A, PL2-620B, PL2-621A, and PL2-621B and proposed A- and B-Level wells at Location A (i.e., PL2-613A and PL2-613B) would be used to monitor groundwater semiannually at the POC for RA 8.
- **Short-Term Groundwater Monitoring.** The south half of RA 8 includes tunnels backfilled with crushed concrete containing detections of PCBs as shown in Figures 6-10C1 and 6-10C2. Although the crushed concrete was placed above the groundwater table, Boeing has sampled PL2-617A, PL2-618A, PL2-619A, PL2-620A, and PL2-621A for PCBs. Short-term groundwater monitoring and data evaluations for PCBs at these wells were previously described in Sections 6.8, 6.9 and 6.12

  Excavation with Off-Site Disposal. Excavation of impacted soil exceedance areas within RA 8 would be performed to meet FMCLs for MoRPH, cPAH, chromium (VI), free cyanide, and arsenic and the leaching SLs for TCE, VC, and ethylbenzene associated with GRPH potentially impacting cVOC-10 and BTEX-7. The depth of the excavation would be determined at the time the work is completed based on soil sampling results and/or confirmation sampling. The depths of the excavations are anticipated to range from 2 to 11.5 feet bgs, resulting in a volume of approximately 320 cy. Additional corrective actions would be conducted in RA 8 for areas that exceed the leaching SLs for cVOCs and ethylbenzene (associated with GRPH) and potentially impact groundwater exceedance areas (cVOC-10 and BTEX-7) if groundwater cleanup levels are not achieved during long-term groundwater monitoring. Excavation to leaching SLs would result in an additional volume of approximately 160 cy.

In addition to the remedial technologies applicable to cVOCs, Adaptive Management processes are reserved to address the potential need for groundwater corrective measures for inorganics and organics:

- **Adaptive Management for Inorganics in Groundwater.** The potential for groundwater treatment technology has been retained for the inorganic constituents represented by exceedance areas Arsenic-3, Arsenic-4, Arsenic-8, Arsenic-11, and Arsenic-12. These exceedance areas are well-delineated and, in some cases, appear stable or decreasing. Although the data for each area vary, the inorganic constituents have generally not been detected at concentrations greater than FMCLs downgradient at the POC, except in a small subset of shoreline monitoring wells (e.g., arsenic at PL2-271A). Ongoing groundwater monitoring data considered through the Adaptive Management process will indicate if any specific corrective action for one or more of these exceedance areas is warranted.

  Where Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations. The Adaptive Management process for inorganic COCs is shown graphically on Figure 6-12.

- **Adaptive Management for Organics in Groundwater.** The potential for groundwater treatment technology has been retained for the organic constituents represented by exceedance areas cVOC-7, cVOC-8, cVOC-12, cVOC-13, and BTEX-8. These exceedance areas are generally well delineated, and those constituents have occasionally been detected at concentrations greater than FMCLs at the POC in a small subset of shoreline monitoring wells (e.g., cVOCs at PL2-618A and PL2-619A).

  Implementation of the proposed corrective measures is expected to achieve FMCLs for these exceedance areas; however, there might be some POC locations that do not achieve or consistently maintain FMCLs over time for organic COCs. A suitable corrective action technology will only be considered if groundwater monitoring data indicate that further consideration of corrective action for one or more of these exceedance areas is warranted.

  Where Adaptive Management for organics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective technology determinations. The Adaptive Management process for organic COCs is shown graphically on Figure 6-13.

- **Adaptive Management for PCBs in Groundwater.** The potential for groundwater treatment technology and additional groundwater monitoring has been retained for PCBs, which have been analyzed for four semiannual events in samples from shoreline monitoring wells PL2-617A, PL2-618A, PL2-619A, and PL2-620A, which are located in RA 7 but are downgradient of tunnels backfilled with crushed concrete containing detections of PCBs in RA 8. PCBs were not detected, using the current analytical method, during the four sampling events completed at these wells. Boeing may temporarily discontinue analyzing for PCB Aroclors in groundwater at those locations.

  In the future, Boeing will conduct PCB analysis in groundwater using a high-sensitivity analytical method (e.g., USEPA Method 1668) to achieve a RL equal to or lower than the WQS, which is the TMCL for PCBs. At this time, USEPA may require sampling for PCBs at wells where PCB sampling had previously been discontinued. Boeing will work with

USEPA through an Adaptive Management process to apply the high-sensitivity PCB analysis method for this ongoing groundwater monitoring, which may include specific requirements for data collection and analysis. As new data collected under this method become available, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and response.

6.13.2 Remedial Alternatives for RA 8

Applicable remedial technologies for soil and groundwater in RA 8 have been assembled into remedial alternatives that are based on media, constituent, and location-specific considerations. In addition to impacted soil and groundwater, the remedial alternatives consider the presence of copper and PCBs greater than the proposed industrial soil FMCL and/or leaching SLs. Assembled groups of remedial technologies are identified as numbered alternatives that are described below and are summarized in Table 6-8B.

Alternative 1 – Corrective Action Not Required with Controls: This remedial alternative is applicable for areas with no active measures, but where the following remedial technologies are used:

- No Corrective Action needed for soil and groundwater
- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics and PCBs

Alternative 1 requires no additional active corrective actions for soil and groundwater. However, Alternative 1 would utilize remedial technologies that are currently in place, including Engineering Controls and Institutional Controls. The protectiveness of this alternative would be evaluated with long-term groundwater monitoring in the shoreline monitoring wells. This alternative serves as the baseline for comparison to other alternatives.

Alternative 2 – Excavation with Off-Site Disposal: This remedial alternative adds excavation with off-site disposal to Alternative 1 and would be expected to decrease the restoration timeframe relative to Alternative 1. Alternative 2 includes the following remedial technologies:

- Excavation with Off-Site Disposal
- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics and PCBs

Alternative AM-1 – Adaptive Management for Inorganics in Groundwater: The Adaptive Management process for inorganics may be combined with any of the previously described alternatives as noted in Table 6-8A. Adaptive Management would be considered if future shoreline monitoring data indicate that inorganic COCs are present at concentrations exceeding FMCLs in groundwater at the POC as described in Section 6.3.8 and Figure 6-12. Where

Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations.

Alternative AM-2 – Adaptive Management for Organics in Groundwater: The Adaptive Management process for organics may be combined with any of the previously described alternatives as noted in Table 6-8A. Adaptive Management would be considered if future shoreline monitoring data indicate that organic COCs are present at concentrations exceeding FMCLs in groundwater at the POC as described in Section 6.3.8 and Figure 6-13. Where Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations.

Alternative AM-3 – Adaptive Management for PCBs in Groundwater: The Adaptive Management process for PCBs may be combined with any of the previously described alternatives as noted in Table 6-8A. Adaptive Management would be considered if future shoreline monitoring data indicate that PCBs are present at concentrations exceeding FMCLs in groundwater at the POC as described in Section 6.3.8. Where Adaptive Management for PCBs is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations.

6.13.3 RA 8 – Remedial Alternative Descriptions and Total Net Benefit Ratings

In accordance with the evaluation process described in Section 6.5, Table 6-8C presents a summary of how effectively the proposed remedial alternatives meet the RCRA criteria. The following summarizes the RA 8 remedial alternatives and provides the net benefit score from Table 6-8C. Evaluation of RA 8 remedial alternatives is provided in detail in Attachment S6C, which includes complete descriptions of the proposed elements and scopes of work for the remedial alternatives.

Alternative 1: Corrective Action Not Required with Controls – Alternative 1 is based on establishing an environmental covenant for the site and utilizing existing engineering controls including security fencing, pavement, and stormwater management to control exposure pathways to the environment. Alternative 1 also includes short- and long-term groundwater monitoring at the POC (i.e., shoreline monitoring). The total net benefit rating for Alternative 1 is 21, as noted in Table 6-8C.

Alternative 2: Excavation with Off-Site Disposal – Alternative 2 includes all the elements of Alternative 1 plus excavation of eight impacted soil exceedance areas within RA 8 to meet industrial soil FMCLs for cPAH, arsenic, chromium (VI), free cyanide, and MoRPH as presented in Figures 6-10A and 6-10B. An estimated 320 cy of soil would be excavated in RA 8. Disposal costs are based on the assumption that a “contained-out” determination for TCE contaminated soils would be obtained from Ecology under the Toxics Waste Program and soil’s final deposition would be in a Subtitle D landfill at volume discounted rates.

Additional corrective actions would be conducted in RA 8 for areas that exceed the leaching SLs for ethylbenzene (associated with GRPH), TCE, and VC and potentially remediate groundwater exceedance areas BTEX-7 and cVOC-10 if groundwater FMCLs are not achieved during long-term groundwater monitoring. Excavation to leaching SLs would result in soil removal of an additional volume of approximately 160 cy.

Soil corrective actions for arsenic at PL2-201B near the old tank farm in the 2-10 Area are not considered for this location because location PL2-201B is an existing groundwater well that is proposed as one of the Upgradient Monitoring Well Network wells (see Table S6A-2 in attachment S6A). Excavation cannot occur at PL2-201B without first decommissioning the groundwater well, which would prevent the development of a groundwater data set for the B-Level of the aquifer at this location. This location is covered with pavement and does not pose a risk of exposure to workers. At some time in the future, when this well is no longer needed, soil exceeding FMCLs for arsenic at this location would be excavated.

Chromium (VI) and free cyanide are present within the footprint of the 2-10 Building at two unique locations at concentrations greater than their respective FMCLs. Soil corrective actions for chromium (VI) and free cyanide at these locations are not considered at this time because they are located inside the 2-10 Building and are beneath a concrete foundation. These two locations do not pose a risk to site workers because the area is covered, which removes the direct contact exposure pathway. Soil at these locations will be removed at some time in the future when the 2-10 Building is demolished.

Soil data for arsenic, chromium (VI), and free cyanide at these locations will be documented in the environmental covenant and retained in the Plant 2 database to provide worker health and safety data in support of future site activities.

Shoreline monitoring wells PL2-258A, PL2-258B, PL2-271A, PL2-214A, PL2-214B, PL2-213A, PL2-612A, PL2-614A, PL2-614B, PL2-615A, PL2-615B, PL2-616A, PL2-617A, PL2618A, PL2619A, PL2-619B, PL2-620A, PL2-620B, PL2-621A, and PL2-621B and the proposed wells at Location A (PL2-613A and PL2-613B) would be used to monitor groundwater at the POC for RA 8. The total net benefit rating for Alternative 2 is 24, as noted in Table 6-1C.

Alternative AM-1: Adaptive Management for Inorganics in Groundwater – If the Adaptive Management process for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations as shown in Figure 6-12. The appropriate strategy resulting from this process cannot be known or evaluated at this time.

Alternative AM-2: Adaptive Management for Organics in Groundwater – If the Adaptive Management process for organics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations as shown in Figure 6-13. The appropriate strategy resulting from this process cannot be known or evaluated at this time.

Alternative AM-3: Adaptive Management for PCBs in Groundwater – If the Adaptive Management process for PCBs is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations. The appropriate strategy resulting from this process cannot be known or evaluated at this time.

6.13.4 RA 8 – Recommended Remedial Alternative

As noted in Table 6-8C, the remedial alternative with the greatest total net benefit is Alternative 2, Excavation with Off-Site Disposal, with a result of 24 out of a possible 30. Previous IMs at Plant 2 have demonstrated that this technology is effective and highly implementable. Comparatively,

cost for implementation of this alternative is not prohibitive and excavation of contaminated soil provides substantial benefit. Alternative 2 is the recommended remedial alternative for RA 8.

Alternative 2 is not designed to directly remediate the BTEX, naphthalene, arsenic, copper and zinc groundwater exceedance areas present in RA 8, but would likely benefit groundwater exceedance areas. Successful completion of Alternative 2 is expected to allow groundwater to return to natural geochemical conditions, which should reduce metals concentrations within approximately 5 years. If future monitoring data indicate inorganic, organic, or PCB FMCL exceedances, then Alternatives AM-1, AM-2, or AM-3, respectively, would be pursued in coordination with EPA.

Supporting technical discussions and rationale for the rating assigned to each of the RCRA Alternative Evaluation Standards are presented in Attachment S6C.

6.14 RA 9 – OA 11 Area

RA 9 encompasses the OA 11 Building 2-72 Area and the former West Bank Substation. This area is located within the paved industrial area, which is primarily covered by concrete and asphalt paving (Figure 6-11A). The 2-72 Building was a small shed used for general storage and has since been demolished. The transformers, formerly located on the historical concrete pad of the West Bank Substation, were also previously removed in 2004, the pad was removed in 2016.

Soil exceeding FMCLs was removed by excavation of the soil sources as part of the OA 11 IM. The Construction Completion Report for the OA 11 IM is presented in Attachment S3A.

Pre-OA 11 IM soil data shows RA 9 contained soil concentrations of GRPH and PCBs that were greater than their respective FMCLs. The OA 11 IM removed these soil sources (some of which exceeded industrial Area FMCLs) that contributed to groundwater exceedance areas BTEX-3, CuZn-2, Arsenic-1, DRPH-4, cVOC-5, and PCB-1 as noted in Figure 6-11A. Removal of these soil sources is also confirmed on the same figure.

It is believed removal of the source soils has impacted (for the better) the historical groundwater exceedance area. Groundwater FMCL exceedance areas in RA 9 prior to the IM did not reach the POC and were small, well delineated, and stable or shrinking. Table 6-9A provides the pre-OA 11 IM groundwater data for historical context. The historical exceedance areas for these constituents are identified in Table 6-9A and Figure 6-11A.

Constituent Exceedance Area	Associated Figures
cVOC-5	Figures 4-2D and 6-11A
BTEX-3	Figures 4-3D and 6-11A
Arsenic-1	Figures 4-4D and 6-11A
CuZn-2	Figures 4-5D and 6-11A
DRPH-4	Figures 4-7D and 6-11A
PCB-1	Figures 4-8D and 6-11A

RA 9 – OA 11 Area

Key Features

OA 11 is primarily located in the paved industrial area of Plant 2; this area is paved and fenced. The area was the subject of an IM completed in October 2016.

COCs Driving Remedy Selection

Groundwater: cVOCs, BTEX, GRPH

Soil: None

Considerations Affecting Remedy Selection: OA 11 IM was conducted in 2016 and consisted of a soil excavation to remove contaminated source soils to depths of 15 feet bgs. Pre-IM groundwater exceedance areas were generally small, well delineated, stable or shrinking and did not reach the POC.

Metal groundwater exceedance areas are suspected to be comprised of false positive results on the basis of data collection or analysis methods.

RCRA Units Associated with Current RA Corrective Action(s)

OA 11 - Building 2-72 Area

POC Monitoring Wells

PL2-614A, PL2-614B, PL2-613A and PL2-613A Not Installed

There are no sample locations with concentrations of COCs exceeding the FMCLs for soil that remain within RA 9. Concentrations of cPAH, TCE, and PCBs exceeding the leaching SLs are present at depths between 8 and 10 feet bgs (exceedance locations and concentrations are presented in Figure 6-11A).

6.14.1 Applicable Remedial Technologies for RA 9

In light of the completion of the IM conducted at OA 11, the remedial technologies applicable to RA 9 is comprised of a short focused list. The remedial alternatives for RA 9 were designed to address the presence of PCBs, DRPH, and BTEX that exceeded groundwater FMCLs prior to conducting the 2016 IM. Pre-IM exceedance areas in RA 9 are presented in Table 6-9A and Figure 6-11A. Table 6-9A identifies the technologies that were considered to address the COCs present in RA 9. Applicable technologies are described in the text that follows:

- **Engineering Controls.** The presence of the existing pavement in the paved industrial area serves as a physical barrier to minimize the potential for infiltration of precipitation to complete the leaching pathway, which could contribute to groundwater exceedance. RA 9 is physically accessible only to site workers. Public exposure would be prevented by physical barriers in the form of pavement or buildings, fencing and Boeing security.
- **Institutional Controls.** Institutional controls in the form of an environmental covenant would require the area to be covered with pavement or building(s). These controls would be consistent with the technology descriptions presented in Section 6.3.
- **Long-term Groundwater Monitoring.** Existing shoreline monitoring wells PL2-614A, and PL2-614B and proposed A- and B-Level- wells at Location A (i.e., PL2-613A and PL2-613B) would be used to monitor groundwater semiannually for VOCs including at the POC for RA 9.
- **Short-term Groundwater Monitoring.** Existing well PL2-007AR and proposed shoreline monitoring well PL2-613A (Location A) would be used to monitor groundwater annually for PCBs for at least four events (Attachment S2B). Continued PCB monitoring will be evaluated through the Adaptive Management process for PCBs. Short-term monitoring would also include VOCs for GRPH and DRPH surrogates BTEX and naphthalene (respectively).

  DGI probe data for metals in RA 9 are likely false positive analytical results. Boeing and USEPA will review the inorganics data from POC wells downgradient of RA 9 to determine the appropriate course of action using the Adaptive Management process for inorganics presented in Figure 6-12.

In addition to the remedial technologies applicable to VOCs, a final approach is retained to address the potential need for groundwater corrective measures for inorganics, organics, and PCBs:

- **Adaptive Management for Inorganics in Groundwater.** The potential for groundwater treatment technology has been retained for the inorganic constituents represented by exceedance areas Arsenic-1 and CuZn-2. These exceedance areas are well-delineated and, generally, appear stable or decreasing. Although the data for each area vary, the inorganic constituents have generally not been detected at concentrations greater than FMCLs downgradient at the POC. Ongoing groundwater monitoring data considered

through the Adaptive Management process will indicate if any specific corrective action for one or more of these exceedance areas is warranted.

If Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations. The Adaptive Management process for inorganic COCs is shown graphically on Figure 6-12.

- **Adaptive Management for Organics in Groundwater.** The potential for groundwater treatment technology has been retained for the organic constituents represented by exceedance areas cVOC-5, BTEX-3, and DRPH-4. These exceedance areas are generally well delineated, and those constituents have occasionally been detected at concentrations greater than FMCLs at the POC in a small subset of shoreline monitoring wells (e.g., cVOCs at PL2-614A).

  Implementation of the proposed corrective measures is expected to achieve FMCLs for these exceedance areas; however, there might be some POC locations that do not achieve or consistently maintain FMCLs over time for organic COCs. A suitable corrective action technology will only be considered if groundwater monitoring data indicate that further consideration of corrective action for one or more of these exceedance areas is warranted.

  If Adaptive Management for organics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective technology determinations. The Adaptive Management process for organic COCs is shown graphically on Figure 6-13.

- **Adaptive Management for PCBs in Groundwater.** The potential for groundwater treatment technology and additional groundwater monitoring has been retained for PCBs represented by exceedance area PCB-1. PCB-impacted soils have been removed from this area and downgradient groundwater will be monitored at PL2-007AR and proposed well PL2-613A (Location A). Boeing will continue to analyze for PCB Aroclors in groundwater at these locations using USEPA Method 8082A with an MDL of approximately 0.01 µg/L and will compare those data to PQL of 0.1 µg/L. After completion of eight semiannual monitoring events, Boeing may request an Adaptive Management response to the data collected from these wells.

  In the future, Boeing will conduct PCB analysis in groundwater using a high-sensitivity analytical method (e.g., USEPA Method 1668) to achieve a RL equal to or lower than the WQS, which is the TMCL for PCBs. At this time, USEPA may require sampling for PCBs at wells where PCB sampling had previously been discontinued. Boeing will work with USEPA through an Adaptive Management process to apply the high-sensitivity PCB analysis method for this ongoing groundwater monitoring, which may include specific requirements for data collection and analysis. As new data collected under this method become available, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and response.

6.14.2 Remedial Alternatives for RA 9

Applicable remedial technologies for groundwater in RA 9 have been assembled into remedial alternatives that are based on media, constituent, and location-specific considerations. In addition to impacted groundwater, the remedial alternatives consider the presence of cVOCs, PCBs, and pending COC cadmium greater than the leaching SLs. Assembled groups of remedial

technologies are identified as focused a numbered alternative described below and are summarized in Table 6-9B.

Alternative 1 – Corrective Action Not Required (with Controls and Monitoring): This remedial alternative is applicable for areas with no active corrective actions, but where the following remedial technologies are used:

- No Corrective Action needed for soil and groundwater
- Institutional Controls
- Engineering Controls
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics and PCBs

Alternative 1 requires no additional active corrective actions for soil and groundwater. However, Alternative 1 would utilize remedial technologies that are currently in place, including Engineering Controls and Institutional Controls. The protectiveness of this alternative would be evaluated with long-term groundwater monitoring in the shoreline monitoring wells. This alternative serves as the baseline for comparison to other alternatives.

Alternative AM-1 – Adaptive Management for Inorganics in Groundwater: The Adaptive Management process for inorganics might be combined with the previously described alternative as noted in Table 6-9A. Adaptive Management would be considered if future shoreline monitoring data indicate that inorganic COCs are present at concentrations exceeding FMCLs in groundwater at the POC as described in Section 6.3.8 and Figure 6-12. Where Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations.

Alternative AM-2 – Adaptive Management for Organics in Groundwater: The Adaptive Management process for organics might be combined with the previously described alternative as noted in Table 6-9A. Adaptive Management would be considered if future shoreline monitoring data indicate that organic COCs are present at concentrations exceeding FMCLs in groundwater at the POC as described in Section 6.3.8 and Figure 6-13. Where Adaptive Management for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations.

Alternative AM-3 – Adaptive Management for PCBs in Groundwater: The Adaptive Management process for PCBs might be combined with the previously described alternative as noted in Table 6-9A. Adaptive Management would be considered if future shoreline monitoring data indicate that PCBs are present at concentrations exceeding FMCLs in groundwater at the POC as described in Section 6.3.8. Where Adaptive Management for PCBs is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations.

6.14.3 RA 9 – Remedial Alternative Descriptions and Total Net Benefit Ratings

In accordance with the evaluation process described in Section 6.5, Table 6-9C presents a summary of how effectively the proposed remedial alternative meets the RCRA criteria. The following summarizes the RA 9 remedial alternatives and provides the net benefit score from Table 6-9C. Evaluation of RA 9 remedial alternative is provided in detail in Attachment S6C, which includes complete descriptions of the proposed elements and scopes of work for the remedial alternative.

Alternative 1: Corrective Action Not Required with Controls – Alternative 1 is based on establishing an environmental covenant for the site and utilizing existing engineering controls including security fencing, pavement, and stormwater management to control exposure pathways to the environment. Alternative 1 also includes short- and long-term groundwater monitoring at the POC (i.e., shoreline monitoring). The total net benefit rating for Alternative 1 is 21, as noted in Table 6-9C.

Alternative AM-1: Adaptive Management for Inorganics in Groundwater – If the Adaptive Management process for inorganics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations as shown in Figure 6-12. The appropriate strategy resulting from this process cannot be known or evaluated at this time.

Alternative AM-2: Adaptive Management for Organics in Groundwater – If the Adaptive Management process for organics is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology determinations as shown in Figure 6-13. The appropriate strategy resulting from this process cannot be known or evaluated at this time.

Alternative AM-3: Adaptive Management for PCBs in Groundwater – If the Adaptive Management process for PCBs is warranted, Boeing will work in coordination with and seek approval from USEPA to develop and implement an appropriate strategy for data evaluation and corrective action technology. The appropriate strategy resulting from this process cannot be known or evaluated at this time.

6.14.4 RA 9 – Recommended Remedial Alternative

As noted in Table 6-9C, the remedial alternative with the greatest total net benefit is Alternative 1, Corrective Action Not Required (with Controls and Monitoring) with a result of 21 out of a possible 30. This technology effectively limits exposure and is highly implementable. Cost for implementation of this alternative is not prohibitive and implementation of institutional and engineering controls coupled with groundwater monitoring provides substantial benefit. Alternative 1 is the recommended remedial alternative for RA 9.

Alternative 1 does not propose active remediation for the cVOC, BTEX, arsenic, zinc, DRPH, and PCB groundwater exceedance areas present or formerly present in RA 9. A significant mass of source material for these COCs was removed in the recently completed IM. If future monitoring data indicate inorganic, organic, or PCB FMCL exceedances, then Alternatives AM-1, AM-2, or AM-3, respectively, would be pursued in coordination with EPA.

Supporting technical discussions and rationale for the rating assigned to each of the RCRA Alternative Evaluation Standards are presented in Attachment S6C.

7.0 RECOMMENDED REMEDIAL ALTERNATIVES

Boeing evaluated the remedial alternatives that were assembled and identified for the specific soil and groundwater conditions at each individual RA based on the four RCRA Alternative Evaluation Standards and Other Factors described in Section 6.4.

This CMS used a focused approach to select recommended remedial alternatives for soil and groundwater; an initial extensive evaluation of other, clearly less applicable remedial alternatives was not performed. USEPA guidance notes that a focused approach is appropriate at sites with relatively straightforward remedial solutions in which standard engineering solutions have proven effective in similar situations (USEPA 1994b).

Soil excavations, ERD, EAD, SVE, and bioventing combined with groundwater monitoring have been successfully performed as IMs at Plant 2. The successful implementation of these remedial technologies demonstrates they are effective in meeting cleanup levels, are protective of human health and the environment, provide long-term reliability, and are readily implemented within the specific physical, geochemical, and hydrogeologic conditions at Plant 2. The USEPA evaluation process resulted in selected remedial alternatives that included these proven technologies combined with engineering and institutional controls, such as paving, fencing and environmental covenants.

Most of the recommended remedial alternatives for the groundwater component are designed to remediate organic COCs, most commonly cVOC groundwater exceedance areas, present in individual RAs. Although there are inorganic COC groundwater exceedance areas present in the majority of the RAs, the recommended remedial alternatives do not directly remediate the inorganic exceedance areas. Successful completion of the recommended remedial alternatives is expected to allow groundwater in each RA to return to natural geochemical conditions, which in turn are expected to reduce metals concentrations within approximately 5 years. If future shoreline monitoring data from any of the RAs indicate inorganic, organic, or PCB FMCL exceedances at unacceptable concentrations, Alternatives AM-1, AM-2, or AM-3, Adaptive Management would be implemented for that specific RA. The recommended remedial alternatives for the soil component are generally designed to meet FMCLs or support groundwater remediation through excavation and off-site disposal.

The recommended corrective measures alternatives for RA 1 through RA 9 are summarized below.

7.1 RA 1 – 2-10 North Sheetpile Area

RA 1 contains the 2-10 North Sheetpile and surrounding area. It is located in the paved industrial area within the footprint of the 2-10 Building (Figure 6-3). A small portion of the RA extends into the unpaved shoreline area below the 2-10 Building overhang. The original source of contamination at RA 1 is the TCE degreaser associated with RCRA Unit AOC 2 10.3A. RA 1 has been the subject of a number of IMs including surrounding the highest levels of contamination with a steel sheetpile to block cVOC migration to the waterway (Attachment S3C). Exceedances of cVOCs in groundwater were identified as the primary issue at RA 1.

As noted in Table 6-1C and in Section 6.6.3, the following three remedial alternatives were evaluated:

- Alternative 1, Corrective Action Not Required (with Controls)
- Alternative 2, Enhanced Reductive Dechlorination (ERD)
- Alternative 2a, ERD and Excavation with Off-Site Disposal

Remedial alternatives were evaluated with the understanding that if future monitoring data indicate inorganic or organic FMCL exceedances, then Alternatives AM-1 or AM-2, respectively, would be pursued in coordination with EPA.

Alternative 2, ERD was identified as the remedial alternative with the greatest total net benefit for RA 1 (Table 6-1C and Section 6.6.4). Previous implementation of ERD IMs at Plant 2, including at RA 1, have demonstrated that this technology is effective for the specific subsurface conditions in RA 1. The use of the existing infrastructure including substrate injection wells and monitoring wells for ongoing ERD IMs at RA 1 make Alternative 2 highly implementable. Comparatively, the estimated cost for implementation of Alternative 2 and the destruction of the cVOCs is not prohibitive and provides substantial benefit.

Alternative 2 ERD includes:

- ERD
- Engineering controls (per Section 6.3.2)
- Institutional controls (per Section 6.3.3)
- Long-term groundwater monitoring for VOCs and inorganics (performed using existing shoreline monitoring wells and as described in Attachment S6A)
- Short-term groundwater monitoring for inorganics and BEHP

7.2 RA 2 – 2-10 South Sheetpile Area

RA 2 is very similar to RA 1 with respect to the physical structures, RCRA unit history, nature of release, and IMs conducted to date. RA 2 contains the 2-10 South Sheetpile and surrounding area. It is located in the paved industrial area within the footprint of the 2-10 Building (Figure 6-4). A small portion of the RA extends into the unpaved shoreline area below the 2-10 Building overhang. The original source of contamination at RA 2 is the TCE degreaser associated with RCRA Unit AOC 2 10.3A. RA 2 has been the subject of a number of IMs including surrounding the highest levels of contamination with a steel sheetpile to block cVOC migration to the waterway (Attachment S3C). Exceedances of cVOCs in groundwater were identified as the primary issue at RA 2.

As noted in Table 6-2C and in Section 6.7.3, the following three remedial alternatives were evaluated:

- Alternative 1, Corrective Action Not Required (with Controls)
- Alternative 2, ERD
- Alternative 2a, ERD and Excavation with Off-Site Disposal

Remedial alternatives were evaluated with the understanding that if future monitoring data indicate inorganic or organic FMCL exceedances, then Alternatives AM-1 or AM-2, respectively, would be pursued in coordination with EPA.

Alternative 2, ERD was identified as the remedial alternative with the greatest total net benefit for RA 2 (Table 6-2C and Section 6.7.4). Previous implementation of ERD IMs at Plant 2, including at RA 2, have demonstrated that this technology is effective for the specific subsurface conditions in RA 2. The continued use of the existing infrastructure, including substrate injection wells and monitoring wells for ongoing ERD IMs at RA 2 make Alternative 2 highly implementable. Comparatively, the estimated cost for implementation of Alternative 2 and the destruction of the cVOCs is not prohibitive and provides substantial benefit. Alternative 2 ERD includes:

- ERD
- Engineering controls (per Section 6.3.2)
- Institutional controls (per Section 6.3.3)
- Long-term groundwater monitoring for VOCs and metals (performed using existing shoreline monitoring wells and as described in Attachment S6A)
- Short-term groundwater monitoring for inorganics

7.3 RA 3 – 2-31 Area

RA 3 is comprised of both paved industrial area and unpaved shoreline areas west of the 2-31 Building and south of the 16th Avenue South Bridge (Figure 6-5). RA 3 occupies an area previously covered by a portion of 2-31 Building that was demolished as part of the 2010-2012 demolition/redevelopment project and that extends into the unpaved shoreline area and the South Habitat Area. The original source of contamination at RA 3 is the TCE degreaser associated with RCRA Unit AOC 2-31.21, which is located within the footprint of the remaining portion of the 2-31 Building and TCE piping that was removed in 2011. RA 3 has been the subject of a corrective action conducted in association with the 2011 TCE pipe removal (Attachment S3C). Exceedance of cVOCs in groundwater were identified as the primary issue along with the presence of crushed concrete used to backfill tunnel excavations above the water table during the 2010-2012 demolition/redevelopment.

As noted in Table 6-3C and in Section 6.8.3, the following three remedial alternatives were evaluated:

- Alternative 1, Corrective Action Not Required (with Controls)
- Alternative 2, ERD
- Alternative 3, Air Sparging/Soil Vapor Extraction (AS/SVE)

Remedial alternatives were evaluated with the understanding if future monitoring data indicate inorganic, organic, or PCB FMCL exceedances, then Alternatives AM-1, AM-2, or AM-3, respectively, would be pursued in coordination with EPA.

Alternative 2, ERD was identified as the remedial alternative with the greatest total net benefit for RA 3 (Table 6-3C and Section 6.8.4). Previous use of ERD as an IM at several locations throughout Plant 2 has demonstrated that this technology is effective and highly implementable.

In addition, the remediation substrate 3D Microemulsion™ (3DMe) was previously added to the top of the water table to initiate ERD within the vadose zone soil excavation overlying cVOC-10 in RA 3. Comparatively, the estimated cost for implementation of Alternative 2 and the destruction of the cVOCs is not prohibitive and provides substantial benefit. Alternative 2 ERD includes:

- ERD
- Engineering controls (per Section 6.3.2)
- Institutional controls (per Section 6.3.3)
- Long-term groundwater monitoring for cVOCs and metals (performed using existing shoreline monitoring wells and as described in Attachment S6A)
- Short-term groundwater monitoring for inorganics, BEHP, and PCBs

Prior to implementing Alternative 2, Boeing would prepare a work plan for an initial subsurface investigation to provide updated data necessary to design an appropriate ERD corrective action for RA 3.

7.4 RA 4 – 2-66 Sheetpile and Surrounding Area

RA 4 contains the 2-66 paved industrial area and unpaved shoreline area and the western portion of the 2-60 paved industrial area, and consists of groundwater with concentrations exceeding the FMCLs (TMCLs for petroleum hydrocarbons) for cVOCs, BTEX, naphthalene, various metals, free cyanide, GRPH, DRPH, and PCBs (Figure 6-6). The original sources of cVOC contamination at RA 4 are the TCE degreaser associated with RCRA Unit AOC 2-66.53 and a leaking TCE storage tank decommissioned in the late 1980s. The area with the highest soil and groundwater concentrations were surrounded by a steel sheetpile containment structure to block cVOC migration to the waterway. A number of IMs have been implemented at RA 4 (Attachment S3C). Exceedances of cVOCs and BTEX in groundwater were identified as the primary issue for this RA.

As noted in Table 6-4C and in Section 6.9.3, the following remedial alternatives were evaluated:

- Alternative 1, Corrective Action Not Required (with Controls)
- Alternative 2, ERD
- Alternative 2a, ERD and Excavation with Off-Site Disposal
- Alternative 3, AS/SVE
- Alternative 3a, AS/SVE and Excavation with Off-Site Disposal

Remedial alternatives were evaluated with the understanding that if future monitoring data indicate inorganic, organic, or PCB FMCL exceedances, then Alternatives AM-1, AM-2, or AM-3, respectively, would be pursued in coordination with EPA.

Alternative 2, ERD was identified as the remedial alternative with the greatest total net benefit for RA 4 (Table 6-4C and Section 6.9.4). Previous ERD IMs performed inside of the 2-66 Sheetpile and at other locations at Plant 2 have demonstrated that this technology is effective and highly implementable for the specific subsurface conditions at RA 4. In addition, the remediation substrate 3DMe was added to the top of the water table to continue ERD within the vadose zone

soil excavation inside of the 2-66 Sheetpile in RA 4. Comparatively, the estimated cost for implementation of Alternative 2 is not prohibitive and its implementation provides substantial benefit. Alternative 2 ERD includes:

- ERD
- Engineering controls (per Section 6.3.2)
- Institutional controls (per Section 6.3.3)
- Long-term groundwater monitoring for VOCs and inorganics (performed using existing shoreline monitoring wells and as described in Attachment S6A)
- Short-term groundwater monitoring for inorganics and PCBs

Prior to implementing Alternative 2 Boeing would prepare a work plan for an initial subsurface investigation to provide updated data necessary to design an appropriate ERD corrective action for RA 4.

7.5 RA 5 – South Yard Area

RA 5 encompasses an area within the paved industrial area along the southern boundary of Plant 2 and includes groundwater with concentrations of cVOCs, BTEX, arsenic, zinc, and DRPH that exceed their TMCLs/FMCLs as shown in Figure 6-7. PCBs and MoRPH are the only constituent groups detected in RA 5 soil samples at concentrations greater than the applicable FMCLs. The main source of cVOC impacts in RA 5, the former cisterns, were removed and excavated prior to the South Yard Area DGI. A number of IMs have been implemented at RA 5 (Attachment S3A). Exceedances of cVOCs, TPH, and BTEX in groundwater are the primary issues, in addition to localized relatively shallow soil impacted with TPH or PCBs greater than FMCLs.

As noted in Table 6-5C and in Section 6.10.3, the following remedial alternatives were evaluated:

- Alternative 1, Corrective Action Not Required (with Controls)
- Alternative 2, ERD
- Alternative 2a, ERD and Excavation with Off-Site Disposal
- Alternative 2b, ERD followed by EAD
- Alternative 2c, ERD, EAD, and Excavation with Off-Site Disposal

Remedial alternatives were evaluated with the understanding that if future monitoring data indicate inorganic or organic FMCL exceedances, then Alternatives AM-1 or AM-2, respectively, would be pursued in coordination with EPA.

Alternative 2a, ERD and Excavation with Off-Site Disposal was identified as the remedial alternative with the greatest total net benefit for RA 5 (Table 6-5C and Section 6.10.4). Previous successful implementation of ERD IMs inside of the 2-66 and 2-10 sheetpiles and at OA 12 have demonstrated that ERD is effective and highly implementable for the specific subsurface conditions at Plant 2. This remedial alternative adds excavation of vadose zone soil to meet soil FMCLs and removal of soil in the BTEX and petroleum hydrocarbon groundwater exceedance

areas. The estimated cost for implementation of Alternative 2a is not prohibitive and provides substantial benefit. Alternative 2 ERD and Excavation with Off-Site Disposal includes:

- Excavation with Off-Site Disposal to meet MoRPH and PCB soil FMCLs and support removal of soil potentially contributing to groundwater exceedance areas
- ERD for cVOCs
- Engineering controls (per Section 6.3.2)
- Institutional controls (per Section 6.3.3)
- Long-term Monitoring for VOCs, arsenic, BTEX, naphthalene
- Short-term Monitoring for inorganics

Prior to implementing Alternative 2, Boeing would prepare a work plan for an initial subsurface investigation to provide updated data necessary to design an appropriate ERD corrective action for RA 5.

7.6 RA 6 – OA 18 Area

RA 6 is a defined area within the paved industrial area that is centered on RCRA Unit OA 18, Building 2-40 East Parking Lot Area (Figure 6-8). The RFI identified a cPAH-impacted area approximately 120 feet wide with a dark, black-stained fill observed in soil borings from 2 to 6 feet bgs. The primary issue is the presence of cPAHs, naphthalene, DRPH, MoRPH, and free cyanide in soil at concentrations greater than their respective FMCLs. RA 6 also contains groundwater exceedance areas associated with cVOCs (cis-DCE and VC), copper, and free cyanide.

As noted in Table 6-6C and in Section 6.11.3, the following remedial alternatives were evaluated:

- Alternative 1, Corrective Action Not Required (with Controls)
- Alternative 2, Excavation with Off-Site Disposal

Remedial alternatives were evaluated with the understanding that if future monitoring data indicate that cVOC concentrations in groundwater do not achieve consistent compliance with their FMCLs within a reasonable timeframe, then Alternative AM-2 would be pursued in coordination with EPA.

Alternative 2, Excavation with Off-Site Disposal was identified as the remedial alternative with the greatest total net benefit for RA 6 (Table 6-6C and Section 6.11.4). Previous IMs at Plant 2 have demonstrated that this technology is effective and highly implementable. Comparatively, cost for implementation of this alternative is not prohibitive and provides substantial benefit. Alternative 2 Excavation with Off-Site Disposal includes:

- Excavation with Off-Site Disposal for cPAHs, naphthalene, free cyanide, DRPH, and MoRPH to approximately 7 feet bgs
- Engineering controls (per Section 6.3.2)
- Institutional controls (per Section 6.3.3)

- Long-term Monitoring (not directly applicable to groundwater exceedance areas or to FMCL exceedances in soil for RA 6; however, A- and B-Level shoreline monitoring wells would be used to monitor groundwater at the POC downgradient from RA 6)

7.7 RA 7 – Unpaved Shoreline Area

South of the 16th Avenue South Bridge, RA 7 consists of the unpaved shoreline area located west of the paved industrial area and adjacent to the Habitat Area (Figure 6-9A). North of the bridge, RA 7 consists of the unpaved shoreline area fronting the Duwamish Waterway, the Habitat Area, and Slip 4 (Figure 6-9B). From 2010-2012 as part of redevelopment, lined stormwater bioswales and treatment vaults were installed in the unpaved shoreline area as part of the new stormwater system. A number of IMs have been implemented at RA 7 including actions related to the Habitat Area and the Southwest Bank Corrective Measure (Attachment S3A). The primary issue in RA 7 is the presence of TCE, GRPH, DRPH, and MoRPH in soil at concentrations exceeding soil FMCLs. The soil impacts are located at a depth of approximately 11 feet bgs at the top of the water table adjacent to the 2-40s Area North Stormwater vault and swale.

As noted in Table 6-7C and in Section 6.12.3, the following remedial alternatives were evaluated:

- Alternative 1, Corrective Action Not Required (with Controls)
- Alternative 2, Bioventing
- Alternative 3, Excavation with Off-Site Disposal

Remedial alternatives were evaluated with the understanding that if future monitoring data indicate inorganic, organic, or PCB FMCL exceedances, then Alternatives AM-1, AM-2, or AM-3, respectively, would be pursued in coordination with EPA.

Alternative 2, Bioventing was identified as the remedial alternative with the greatest total net benefit for RA 7 (Table 6-7C and Section 6.12.4). Previous implementation of bioventing at OA 9 has demonstrated that this technology is effective for enhancing the biological degradation of petroleum hydrocarbons and non-chlorinated VOCs. An active bioventing system including bioventing wells, air distribution piping, and a blower would be installed. Air would be injected through the wells to treat soil impacted with GRPH, DRPH, and MoRPH. Blower operation and maintenance activities would consist of regular checks of the blower operation and calibration of the airflow rates. Alternative 2 Bioventing includes:

- Bioventing
- Engineering controls (per Section 6.3.2)
- Institutional controls (per Section 6.3.3)
- Long-term Monitoring for cVOCs
- Short-term Monitoring for inorganics, free cyanide, BEHP, and PCBs

7.8 RA 8 – Paved Industrial Area

RA 8 encompasses the entire paved industrial area, except for those areas included with the other RAs. RA 8 is primarily covered by concrete and asphalt paving, buildings, roadways, and small landscape stripes (Figures 6-10A and 6-10B). A large portion of the paved industrial area south

of the 16th Avenue South Bridge was involved in the 2010-2012 demolition/redevelopment project where impacted soil was removed and tunnel areas were backfilled above the water table with crushed concrete. RA 8 contains groundwater exceedance areas variably associated with cVOCs (cDCE, TCE, and VC), benzene, naphthalene, arsenic, copper, zinc, nickel, free cyanide, and PCBs. The groundwater FMCL exceedance areas in RA 8, however, do not reach the POC and are generally small, well-delineated, and stable or shrinking. There are also eight locations where COCs exceed their respective soil FMCLs for arsenic, chromium (VI), free cyanide, cPAH, and MoRPH.

As noted in Table 6-8C and in Section 6.13.3, the following remedial alternatives were evaluated:

- Alternative 1, Corrective Action Not Required (with Controls)
- Alternative 2, Excavation with Off-Site Disposal

Remedial alternatives were evaluated with the understanding that if future monitoring data indicate inorganic, organic, or PCB FMCL exceedances, then Alternatives AM-1, AM-2, or AM-3, respectively, would be pursued in coordination with EPA.

Alternative 2, Excavation with Off-Site Disposal was identified as the remedial alternative with the greatest total net benefit for RA 8 (Table 6-8C and Section 6.13.4). Previous IMs at Plant 2 including IMs within RA 8 have demonstrated that this technology is effective and highly implementable. Comparatively, cost for implementation of this alternative is not prohibitive and provides substantial benefit. Alternative 2 Excavation with Off-Site Disposal includes:

- Excavation with Off-Site Disposal for arsenic, chromium (VI), free cyanide, cPAH, and MoRPH to approximately 11 feet bgs
- Engineering controls (per Section 6.3.2)
- Institutional controls (per Section 6.3.3)
- Long-term Monitoring (not directly applicable to groundwater exceedance areas or to FMCL exceedances in soil for RA 8; however, A- and B-Level shoreline monitoring wells would be used to monitor groundwater at the POC downgradient from RA 8)
- Short-term Monitoring for inorganics and PCBs.

7.9 RA 9 – OA 11 Area

RA 9 is a defined triangular-shaped area within the southwest portion of Plant 2's paved industrial area. The RA is centered on RCRA Unit OA 11 Building 2-72 Area (Figure 6-11A). The 2-72 Building was a small storage building located east of the former Seattle City Light substation. The discovery of PCB impacted soil during a small construction project in 2001 led to a series of investigations and small soil removal projects which culminated with the 2016 OA 11 IM.

Historically, until 2016 the primary issue was the presence of PCBs and TPH in soil at concentrations greater than their respective FMCLs. RA 9 also historically contained groundwater exceedance areas associated with cVOCs (cDCE, TCE and VC), arsenic, zinc, TPH and PCBs.

As noted in Table 6-16C and in Section 6.14.3, the following remedial alternatives were evaluated:

- Alternative 1, Corrective Action Not Required (with Controls and Monitoring)

RA 9 historically contained groundwater exceedance areas variably associated with the groundwater COCs identified above. The groundwater FMCL exceedance areas in RA 9, however, did not reach the POC and were generally small, well-delineated, and stable or shrinking. The single remedial alternative was evaluated with the understanding that if future monitoring data indicate inorganic, organic, or PCB FMCL exceedances, then Alternatives AM-1, AM-2, or AM-3, respectively, would be pursued in coordination with EPA.

Alternative 1, Corrective Action Not Required (with Controls and Monitoring) was identified as the recommended remedial alternative with a total net benefit score of 21 for RA 9 (Table 6-9C and Section 6.14.4). Cost for implementation of this alternative is not prohibitive and provides adequate protection while monitoring to determine if one of the adaptive management processes for inorganic, organic or PCBs is required to achieve TMCLs/FMCLs in groundwater.

Alternative 1 Corrective Action Not Required (with Controls and Monitoring) includes:

- Engineering controls (per Section 6.3.2)
- Institutional controls (per Section 6.3.3)
- Long-term Monitoring for VOCs
- Short-term Monitoring for inorganics and PCBs

7.10 Conclusion

The corrective measures recommended for RA 1 through RA 9 in Volume X of the CMS Report result from rigorously applying the USEPA alternative evaluation process to all data and current conditions at Plant 2, and then by considering all potential remedial alternatives for the property against standard criteria. When finalized through the SOB and public comment process and detailed through the CMI phase, these recommendations collectively represent a comprehensive set of actions to augment and complete prior corrective actions implemented by Boeing under USEPA oversight since the early 1990s.

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Tables

Table 1-1: RCRA Dangerous Waste Units

SWMU[1]	Building	TSD Unit	Description	SWMU Certified Closed	RCRA Corrective Action[2]	Certification of Closure Date
2-104.71 (OA16)	2-104	1	Central Drummed Waste Staging Area (container storage area)	Yes	Yes	February 25, 2015
2-91.70	2-91	2	Deactivated Waste Oil & Coolant Hold Area (sump and tank system)	Yes	Yes	January 5, 1995
2-31.18	2-31	3	Area B Acid Waste Hold Tank (tank system)	Yes	Yes	February 25, 2015
2-09.2	2-09, 2-10	4	Chrome Waste Tanks	Yes	Yes	February 25, 2015
2-01.1	2-01	5	Landing Gear Cleaning Sump	Yes	NA	July 21, 1992
2-31.20	2-31	6	Deactivated Cyanide Hold Area	Yes	Yes	January 5, 1995

Notes:
[1]Solid Waste Management Unit (SWMU) (RCRA Docket Number 1092-01-22 3008(h) Order, pages 34-36).

[2] RCRA Corrective Action - Any residual subsurface soil and groundwater contamination is addressed through the Resource Conservation and Recovery Act (RCRA) Corrective Action as administered through the US Environmental Protection Agency Region 10 Order (RCRA Docket Number 1092-01-22 3008(h), effective on January 18, 1994).

Table 1-2: Summary of RCRA Units

Unit	DGI Area	Remediation Area	Building/Area	Description	Management Area	Status	Reference Documents	Regulatory Status (see notes)
Remediation Area 1								
AOC 2-10.1AA	2-10 Area	1	2-10	Hydraulic Stamp Machines and Sumps	Industrial	Decommissioned by 2000.	Weston 2000a, EPI and Golder 2009c	Uplands CMS
AOC 2-10.3A	2-10 Area	1	2-10	North TCE Degreaser	Industrial	Decommissioned and removed in 1993.	EPI and Golder 2009c	Uplands CMS
Remediation Area 2								
SWMU 2-10.4	2-10 Area	2	2-10	Zyglo Penetrant Spray Booth	Industrial	Decommissioned in 1992. Sump filled with concrete.	EPI and Golder 2009c, USEPA 2000b	NFA
AOC 2-10.2A	2-10 Area	2	2-10	Decommissioned Machine Sumps	Industrial	Decommissioned by 2000.	Weston 2000a, EPI and Golder 2009c	Uplands CMS
AOC 2-10.4A	2-10 Area	2	2-10	South TCE Degreaser	Industrial	Decommissioned and removed in 1993.	EPI and Golder 2009c	Uplands CMS
AOC 2-10.6A	2-10 Area	2	2-10	Quench Tank	Industrial	Tanks removed in mid-1990s.	EPI and Golder 2009c	Uplands CMS
Remediation Area 3								
SWMU 2-31.18	2-31 Area	3	2-31	Area B Acid Waste Hold Tank	Industrial	Decommissioned in 1993. Closure Certification 2015.	EPI and Golder 2009a, Ecology 1995b, 2015	Above ground TSD Closure, subsurface will be addressed by Uplands CMS
SWMU 2-41.33	2-40 Area	3	2-41	Deactivated Anodic Tank Line	Industrial	Removed in 1993.	EPI and Golder 2008a	Uplands CMS
SWMU 2-41.34	2-40 Area	3/7	2-41	Tunnel Area	Industrial	Removed in 2011.	USEPA 2000b, Golder 2011b	NFA, Uplands CMS
SWMU 2-41.36	2-40 Area	3/7/HA	2-41	Underflow Flume	Shoreline	Removed in 2011.	Golder 2011b	DSOA CMS for Sediment
AOC 2-41.32	2-40 Area	3	2-41	Deactivated Paint Booths and Sump	Industrial	Removed in 2011.	Golder 2011b	Uplands CMS
Remediation Area 4								
SWMU 2-64.48	2-60 Area	4	2-63, 2-64	Underground Waste Tank	Industrial	Removed in 2003.	Golder 2007a	Uplands CMS
SWMU 2-64.49	2-60 Area	4	2-64	Air Compressor Building Sump and Accumulation Area	Industrial	Removed in 2007.	Golder 2007b	Uplands CMS
SWMU 2-65.50	2-60 Area	4	2-65	Machine Pit	Industrial	Filled in 2001.	USEPA 2004	NFA, Uplands CMS
SWMU 2-70.55	2-60 Area	4	2-65	East Steam Clean Area and UST	Industrial	Removed in 1998.	USEPA 2000b, EPI et al. 2005a	NFA, Uplands CMS
SWMU 77.B	2-60 Area	4	2-64	PCB Retention Tank	Industrial	Removed in 1986.	USEPA 2004, EPI et al. 2005a	NFA, Uplands CMS
SWMU 78.C	2-60 Area	4	2-64, 2-65	Oil/water Separator	Industrial	Removed in 2007.	Golder 2008a	Uplands CMS
OA 1 and OA 2	2-66 Area	4/SWBCM	2-66	Building 2-66 Southwest and Building 2-66 Soil	Industrial	Groundwater Remediation System. Soil IM 2010/2011.	EPI and Golder 2006, Golder 2011b	Uplands CMS
OA 9 (including SWMU 2-78.6)	2-60 Area	4	2-44, 2-51	Former USTs PL-16, -17, -18 and SWMU 2-78.6	Industrial	USTs removed in 1986. SWMU 2-78.6 removed in 2011.	EPI et al. 2005a, 2011b	Uplands CMS
OA 12	2-60 Area	4/8	2-63, 2-64, 2-65	Building 2-63 Area	Industrial	Soil IM 2010/2011.	Golder 2011b	Uplands CMS
OA 14	2-66 Area	4/7	2-49	Building 2-49 Machine Pits	Industrial	Backfilled in 1991. Soil IM 2010/2011.	EPI and Golder 2006. Golder 2011b	Uplands CMS
OA 17.13	2-66 Area	4	2-49	Transformer Vault 13	Industrial	Removed in 2011.	USEPA 2000b, Golder 2011b	NFA, Uplands CMS
OA 23.1 and 23.2	2-60 Area	4/8	2-62, 2-63, 2-64, 2-65, 2-66	Stormwater Lines X & Y	Industrial	Removed in 2007.	Golder 2008a	Uplands CMS
AOC 2-66.52	2-66 Area	4	2-66	Machine Pit	Industrial	Removed in 1992.	EPI and Golder 2006	Uplands CMS
AOC 2-66.53	2-66 Area	4	2-66	TCE Degreaser	Industrial	Removed in 1993.	EPI and Golder 2006	Uplands CMS

Table 1-2: Summary of RCRA Units

Unit	DGI Area	Remediation Area	Building/Area	Description	Management Area	Status	Reference Documents	Regulatory Status (see notes)
AOC 2-108.72	2-66 Area	4	2-108	Wet Paint Booths	Industrial	Decommissioned in 1993.	USEPA 2000b	NFA, Uplands CMS
AOC 2-108.73	2-66 Area	4	2-108	Paint Booth Sump	Industrial	Filled with concrete in 1993.	USEPA 2000b, Golder 2011b	NFA, Uplands CMS
Remediation Area 5								
SWMU 2-78.1	South Yard Area	5	Reclamation Yard	Oil/water Separator	Industrial	Operating	USEPA 2000b, EPI et al. 2005b	NFA, Uplands CMS
SWMU 2-80.56	South Yard Area	5	2-80	Sink Sump	Industrial	Removed in 1998.	EPI et al. 2005b	Uplands CMS
SWMU 2-80.57	South Yard Area	5	2-80	Generator Sump	Industrial	Decommissioned in 1993.	EPI et al. 2005b	Uplands CMS
SWMU 2-87.65	South Yard Area	5	2-87	Machine Pit	Industrial	Removed in 1999.	EPI et al. 2005b	Uplands CMS
SWMU 2-89.68	South Yard Area	5	Reclamation Yard	Reclamation Yard	Industrial	Decommissioned in 1996	EPI et al. 2005b	Uplands CMS
SWMU 2-91.70	South Yard Area	5	2-91	Deactivated Waste Oil and Coolant Hold Area	Industrial	Closed in 1993. Closure Certification 1995.	EPI et al. 2005b, Ecology 1995a, 2015.	Above ground TSD Closure, subsurface will be addressed by Uplands CMS
SWMU 2-104.71	South Yard Area	5	Reclamation Yard	Central Drummed Waste Staging Area (aboveground structures). OA 16 includes any residual subsurface soil or groundwater contamination.	Industrial	Closed in 1994. Closure Certification 2015.	EPI et al. 2005b, Ecology 1995b, 2015.	Above ground TSD Closure, subsurface will be addressed by Uplands CMS
SWMU 78.5	South Yard Area	5	Between 2-80 and 2-85	Oil/water Separator	Industrial	Operating	Weston 2001	Uplands CMS
SWMU 78.B	South Yard Area	5	2-87	Oil/water Separator	Industrial	Removed in 1998.	USEPA 2000b, EPI et al. 2005b	NFA, Uplands CMS
SWMU 79.A	South Yard Area	5	East of 2-88	Cistern Sumps 1,2,3	Industrial	Removed in 1986.	EPI et al. 2005b	Uplands CMS
SWMU 79.B	South Yard Area	5	East of 2-88	Cistern Sump 4	Industrial	Removed in 1986.	EPI et al. 2005b	Uplands CMS
OA 3	South Yard Area	5	2-80	Former UST PL-23	Industrial	Removed in 1992.	USEPA 2004	NFA, Uplands CMS
OA 16	South Yard Area	5	2-104	Soil and Groundwater Contamination in Central Drummed Waste Staging Area (SWMU 2-104.71)	Industrial	Soil IM in 1999.	EPI et al. 2005b	Uplands CMS
AOC 2-80.58	South Yard Area	5/8	2-80	Deactivated Sump	Industrial	Removed prior to 1992.	EPI et al. 2005b	Uplands CMS
AOC 2-84.62	South Yard Area	5	2-84	Machine Pit	Industrial	Decommissioned between 1996 and 2000.	USEPA 2004, Weston 2000a	NFA, Uplands CMS
AOC 2-86.63	South Yard Area	5	2-86	Wet Paint Booth	Industrial	Removed in 1992.	EPI et al. 2005b	Uplands CMS
Remediation Area 6								
OA 18	2-40 Area	6	2-40	Building 2-40 East Parking Lot Area	Industrial	Remaining	EPI and Golder 2008a	Uplands CMS
Remediation Area 7								
SWMU 2-01.1	North Area	7/8	2-01	Land Gear Cleaning Sump	Industrial	Closed in 1992. Closure Certification 1992.	EPI and Golder 2008b, Ecology 1992, 2015	NFA, TSD above ground and subsurface Closure
SWMU 2-41.30	2-40 Area	7	2-41	Manhole Vault	Industrial	Removed in 2011.	USEPA 2004, Golder 2011b	NFA, Uplands CMS
OA 17.8	2-40 Area	7/8	2-44	Transformer Vault 8	Industrial	Removed in 2011.	USEPA 2000b, Golder 2011b	NFA, Uplands CMS
Remediation Area 8								
SWMU 2-10.7	2-10 Area	8	2-10	Paint Strip Tank Line	Industrial	Tanks removed in 1994.	EPI and Golder 2009c, USEPA 2000b	Uplands CMS
SWMU 2-10.8	2-10 Area	8	2-10	Anodic and Alodine Tank Lines	Industrial	Tanks decommissioned in 1993.	EPI and Golder 2009c, USEPA 2000b	Uplands CMS

Table 1-2: Summary of RCRA Units

Unit	DGI Area	Remediation Area	Building/Area	Description	Management Area	Status	Reference Documents	Regulatory Status (see notes)
SWMU 2-10.9	2-10 Area	8	2-10	Aluminum Chem Mill Area	Industrial	Decommissioned in 1993.	EPI and Golder 2009c	Uplands CMS
SWMU 2-15.13	2-10 Area	8	2-15	Boiler Valve Pit and USTs (PL-7 and PL-8)	Industrial	Tanks removed in 1992.	EPI and Golder 2009c, USEPA 2000b	NFA
SWMU 2-15.14	2-10 Area	8	2-15	Bulk Storage Tank Pit, Oil/Water Separator, and Oil Holding Tank	Industrial	Operating.	EPI and Golder 2009c, USEPA 2000b	NFA
SWMU 2-15.7A	2-10 Area	8	2-15	Two Waste Storage Tanks (PL-52 and PL-53)	Industrial	PL-52 removed in 2006. PL-53 operating as an oil/water separator.	EPI and Golder 2009c	Uplands CMS
SWMU 2-31.20	2-31 Area	8	2-31	Deactivated Cyanide Hold Area	Industrial	Closed in 1993. Closure Certification 1995.	USEPA 2000b, EPI and Golder 2009a, Ecology 1995b, 2015	NFA, TSD Closure above ground and subsurface, Uplands CMS
SWMU 2-31.22	2-31 Area	8	2-31	Brush Plating Area	Industrial	Decommissioned in 1995.	USEPA 2000b, EPI and Golder 2009a	NFA, Uplands CMS
SWMU 2-31.23	2-31 Area	8	2-31	Ammonium Persulfate Tank	Industrial	In place.	USEPA 2000b, EPI and Golder 2009a	NFA, Uplands CMS
SWMU 2-31.24	2-31 Area	8	2-31	Sodium Hydroxide Developer Room	Industrial	Ceased operating in 1995.	USEPA 2000b, EPI and Golder 2009a	NFA, Uplands CMS
SWMU 2-31.25	2-31 Area	8	2-31	Anodize Aluminum Room	Industrial	Removed in 1995	USEPA 2000b, EPI and Golder 2009a	NFA, Uplands CMS
SWMU 2-31.26	2-31 Area	8	2-31	Anodizing Tank Line	Industrial	Removed in 1995.	EPI and Golder 2009a	Uplands CMS
SWMU 2-41.31	2-40 Area	7/8	2-41	Machine Pits	Industrial	Removed in 2011.	Golder 2011b	Uplands CMS
SWMU 2-62.43	2-60 Area	8	2-62	Tank Line	Industrial	Removed in 2003.	USEPA 2000b	NFA, Uplands CMS
SWMU 2-63.47	2-60 Area	8	2-63	Dilute Chrome Tank	Industrial	Removed in 1990s.	EPI et al. 2005a	Uplands CMS
SWMU 77.A	2-60 Area	8	2-62	PCB Retention Tank	Industrial	Removed in 1986.	USEPA 2000b, EPI et al. 2005a	NFA, Uplands CMS
SWMU 78.7	2-10 Area	8	2-10	Oil/Water Separators	Industrial	Operating.	EPI and Golder 2009c	Uplands CMS
SWMU 78.A	2-10 Area	8	2-10	Oil/Water Separator	Industrial	Operating.	EPI and Golder 2009c	Uplands CMS
SWMU 79.C	South Yard Area	8	Southeast of 2-83	Cistern Sump 5	Industrial	Removed in 1955.	EPI et al. 2005b	Uplands CMS
OA 4	2-10 Area	8	2-10, 2-15, 2-31	Scattered PCB Exceedances	Industrial	Remaining.	EPI and Golder 2009c	Uplands CMS
OA 5	2-10 Area	8	2-15	Fuel Station Area (USTs PL-9, PL-10, and PL-11)	Industrial	Tanks removed in 1986.	EPI and Golder 2009c	Uplands CMS
OA 6	2-10 Area	8	2-15	Northeast Area	Industrial	Remaining.	EPI and Golder 2009c	Uplands CMS
OA 7	2-40 Area	8	2-40	Building 2-40 Soil	Industrial	Soil IM 2010/2011	Golder 2011b	Uplands CMS
OA 8 (SWMU 2-09.2)	2-10 Area	8	2-09	Building 2-09 Chrome Waste Tanks (SWMU 2-09.2)	Industrial	Tanks and surface structures closed in 1993. Closure Certification 2015.	EPI and Golder 2009c, Weston 2003, Ecology 1995b, 2015	Above ground TSD Closure, subsurface will be addressed by Uplands CMS
OA 10	South Yard Area	8	2-80, 2-85	Former UST PL-20	Industrial	Removed in 1986.	EPI et al. 2005b	Uplands CMS
OA 13	2-40 Area	8	2-44	Building 2-44 Steam Drain	Industrial	Removed in 2011.	Golder 2011b	Uplands CMS
OA 15	2-10 Area	8	2-15	Building 2-15 Steam Clean Sump	Industrial	Removed in 1994.	EPI and Golder 2009c	Uplands CMS
OA 17.2	2-40 Area	8	2-41	Transformer Vault 2	Industrial	Removed in 2011.	USEPA 2000b, Golder 2011b	NFA, Uplands CMS
OA 17.4	2-31 Area	8	2-25	Transformer Vault 4	Industrial	Removed in 2011.	USEPA 2000b, EPI and Golder 2009a	NFA, Uplands CMS
OA 17.5	2-40 Area	8	2-44	Transformer Vault 5	Industrial	Removed in 2011.	USEPA 2000b, Golder 2011b	NFA, Uplands CMS
OA 17.6	2-40 Area	8	2-44	Transformer Vault 6	Industrial	Removed in 2011.	USEPA 2000b, Golder 2011b	NFA, Uplands CMS

Table 1-2: Summary of RCRA Units

Unit	DGI Area	Remediation Area	Building/Area	Description	Management Area	Status	Reference Documents	Regulatory Status (see notes)
OA 17.7	2-40 Area	8	2-41	Transformer Vault 7	Industrial	Removed in 2011.	USEPA 2000b, Golder 2011b	NFA, Uplands CMS
OA 21	2-40 Area	8	2-44	Building 2-44 Machine Shop Area	Industrial	Removed in 2011.	Golder 2011b	Uplands CMS
AOC 2-10.1AB	2-10 Area	8	2-10	Hydraulic Stamp Machines and Sumps	Industrial	Decommissioned by 2000.	Weston 2000a, EPI and Golder 2009c	Uplands CMS
AOC 2-10.5	2-10 Area	8	2-10	Paint Booth Area	Industrial	Decommissioned by 2000.	EPI and Golder 2009c	Uplands CMS
AOC 2-10.5A	2-10 Area	8	2-10	Polishing Tank and Former Paint Booth	Industrial	Removed by 2000.	EPI and Golder 2009c, USEPA 2000b	NFA
AOC 2-31.21	2-31 Area	8	2-31	TCE Degreaser	Industrial	Removed in 1995.	EPI and Golder 2009a	Uplands CMS
AOC 2-62.45	2-60 Area	8	2-62	Paint Booths and Sumps	Industrial	Removed in 2003.	EPI et al. 2005a	Uplands CMS
AOC 2-62.46	2-60 Area	8	2-62	Paint Booth Sump	Industrial	Removed in 2003.	EPI et al. 2005a	Uplands CMS
Remediation Area 9								
OA 11	2-66 Area	9	2-72	Building 2-72 Area	Industrial	Soil IM 2010/2011.	Golder 2011b. Attachment D	Uplands CMS, Attachment S1B
Habitat Area								
SWMU 2-41.35	2-40 Area	HA	2-41	Quench Tanks	Shoreline	Decommissioned in 1992. Removed between 1992 and 2008.	EPI and Golder 2008a	DSOA CMS for Sediment
OA 20	2-40 Area	HA	2-41	Outfall No. 23 Area	Shoreline	DSOA	EPI and Golder 2008a	DSOA CMS for Sediment
OA 22.B	2-40 Area	HA	2-41	Outfall No. 16 Area	Shoreline	DSOA	EPI and Golder 2008a	DSOA CMS for Sediment
AOC 2-41.29	2-40 Area	HA	2-41	TCE Degreaser	Shoreline	Removed in 1993.	EPI and Golder 2008a	DSOA CMS for Sediment
Southwest Bank Corrective Measure								
OA 19	2-66 Area	SWBCM	2-49	Building 2-49 Stretch Press Pit and Outfall No. 12	Shoreline	Decommissioned.	EPI and Golder 2006	DSOA CMS for Sediment
OA 22.A	2-40 Area	SWBCM	2-41	Outfall No. 14 Area	Shoreline	DSOA	EPI and Golder 2008a	DSOA CMS for Sediment

Notes:
1. Uplands CMS: Unit is being evaluated as part of the Uplands CMS report.
2. NFA: Unit has a documented NFA status approval on file (see references for further detail).
3. Ecology approved the closure of the above ground portion the TSDs (see references for further detail.)
4. See Section 1 of the CMS Report and Attachment S1A for figures showing RCRA units and CMS areas.

Abbreviations:

AOC - Area of Concern
CMS - Corrective Measures Study
DGI - Data Gap Investigation
DSOA - Duwamish Sediment Other Area
Ecology - Washington State Department of Ecology
EPI - Environmental Partners, Incorporated
HA - Habitat Area
IM - Interim Measure
NFA - No Further Action
OA - Other Area
PCB - Polychlorinated Biphenyls
PL - Plant
SWBCM - Southwest Bank Corrective Measure
SWMU - Solid Waste Management Unit
TCE - Trichloroethene
TSD - Treatment Storage and Disposal
USEPA - United States Environmental Protection Agency
UST - Underground Storage Tank

Table 2-1
Action-Specific Groundwater Sampling Requirements based on Data Quality Issues

Analyte	Issue	Requirement	Outcome
Arsenic	Saline matrix interference effects in all C-Level samples and those A- and B-Level samples with high salinity.	Perform future metal analyses in groundwater using U.S. Environmental Protection Agency (USEPA) Method 200.8 by Inductively Coupled Plasma Dynamic Reaction Cell Mass Spectrometry (ICP-DRC-MS). Sample wells in Shoreline Monitoring Well Network at low tide.	Arsenic and copper are expected to remain constituents of concern (COCs) in groundwater; however concentrations in the more saline wells are expected to be less than those in the historical data. Zinc is expected to be eliminated as a COC.
Copper and Zinc	Zinc exceedances at locations PL2-602B and PL2-603B may be false positives caused by sampling wells soon after development.		
Nickel	Detections in PL2-621A that are greater than the Final Media Cleanup Level (FMCL).		Nickel is retained as a pending groundwater COC at well PL2-621A. Boeing will reevaluate the status of nickel as a COC after completion of 8 semiannual monitoring events at this location.
Cadmium	Original detection limit was greater than the Target Media Cleanup Level (TMCL); the new method used for cadmium contained a saline matrix interference similar to nickel.		Cadmium is a pending groundwater COC at locations PL2-614A, PL2-619B, and PL2-621A. Boeing will reevaluate cadmium's status as a COC after completion of 8 semiannual monitoring events at these locations.
Free Cyanide	The analytical methods used for cyanide analyses during the data gap investigation did not quantify the specific cyanide fraction used to develop the FMCL.	Conduct monitoring for free cyanide, rather than total and/or weak acid dissociable (WAD) cyanide, at locations downgradient of areas where cyanide was previously detected.	Free cyanide is a pending groundwater COC at locations PL2-615A, PL2-619A, and PL2-619B. Boeing will reevaluate the status of free cyanide as a COC (and potential future groundwater monitoring requirements) after completion of 4 semiannual monitoring events at these locations. If concentrations exceed the FMCL at any particular well during any of these events, Boeing will perform 4 additional rounds of sampling prior to data evaluation.
bis(2-ethylhexyl)phthalate (BEHP)	Scattered, isolated hits limited to 2008.	Conduct BEHP monitoring at select locations to confirm previous detections were false positives as a result of laboratory contamination.	BEHP is a pending groundwater COC. It will be analyzed at PL2-258A, PL2-621A, PL2-620A, and PL2-619A in 4 sampling events. Boeing will reevaluate BEHP's status as a COC (and potential future groundwater monitoring requirements) after completion of 4 semiannual monitoring events at these locations. If concentrations exceed the FMCL at any particular well during any of these events, Boeing will perform 4 additional rounds of sampling prior to data evaluation.
Total Polychlorinated Biphenyls (PCBs)	The TMCL is based on the November 2016 Washington Clean Water Act-Effective Criterion, which is below the practical quantitation limit that can be achieved with Boeing's analytical method. Recent studies show that there are PCBs above the TMCL throughout the Lower Duwamish Waterway, and that broader source control and PCB reduction efforts are required before compliance with the TMCL can be achieved.	Conduct PCB monitoring at locations where PCBs are known or suspected to be present in groundwater. Conduct future monitoring with a more sensitive analytical method; implement an adaptive management approach to address PCBs in groundwater in coordination with USEPA.	Total PCBs is a groundwater COC, though sampling with the current method (USEPA Method 8082) may be discontinued at locations where PCBs have not been detected at concentrations less than the method detection limit of approximately 0.01 micrograms per liter (µg/L). Boeing will complete 8 semiannual monitoring events at location PL2-621A, PL2-007AR, and PL2-013A. In the future, USEPA will require Boeing to complete additional sampling using a high-sensitivity method (e.g., USEPA Method 1668), which may include performing additional analysis at wells that previously did not have detections for PCBs.
Arsenic in PL2-612A	Arsenic was detected at concentrations significantly greater than its FMCL in A-Level probe locations upgradient of well PL2-612A but was only 1.1 µg/L in the sample from PL2-612A.	Conduct arsenic monitoring at replacement well PL2-612AR to confirm previous probe sample detections were false positives.	Arsenic data from 4 events will be evaluated to determine response at PL2-612AR. If concentrations exceed the FMCL at any particular well during any of these events, then Boeing will perform 4 additional rounds of sampling prior to data evaluation.

Table 2-2
Groundwater TMCLs and COPCs

CAS Number	Constituent of Potential Concern[1]	Target Media Cleanup Levels (TMCLs)					2017 Proposed FMCL (µg/L)
		Original TMCL from Approved 2011 TMCL Tech Memo (µg/L)	Revisions to TMCLs for the 2014 CMS Submittal		Revisions to TMCLs for the Draft 2017 CMS Submittal		
			Revised TMCL[2,3] (µg/L)	Basis for Change[2,3]	Revised TMCL[3,4] (µg/L)	Basis for Change[3,4]	
Dissolved Metals							
18540-29-9	Aluminum	87	Not retained; see text.	Natural condition.	NA; Not retained.		NA
7440-66-6	Barium	120	820	BCF correction.	770	Transcription error in October 2014 Draft CMS Submittal.	770
7440-02-0	Cadmium	0.25	0.56	Hardness correction.	0.21	Toxicity factor update.	0.21
7782-49-2	Chromium(VI)	0.58	No change.		No change.	Toxicity factor update; update did not change TMCL.	0.58
7440-43-9	Cobalt	4.8	Not retained.	Removal of drinking water surrogate.[5]	NA; Not retained.		NA
7439-92-1	Iron	1000	Not retained; see text.	Natural condition.	NA; Not retained.		NA
7440-22-4	Lead	2.5	6.1	Hardness correction.	No change.		6.1
7440-39-3	Manganese	2000	Not retained; see text.	Natural condition.	NA; Not retained.		NA
7440-48-4	Nickel	8.2	No change.		No change.		8.2
7429-90-5	Selenium	5.0	No change.		No change.		5
7439-89-6	Silver	22	No change.		No change.		22
7439-96-5	Vanadium	140	No change.		No change.	Toxicity factor update; update did not change TMCL.	140
7440-66-6	Zinc	56	No change.		No change.		56
Total Metals							
7440-38-2	Arsenic	8.0	No change.		No change.		8.0
7440-50-8	Copper	8.0	No change.		No change.		8.0
Other Inorganics							
57-12-5	Cyanide (free)	1.0	No change.	Toxicity factor update; update did not change TMCL.	No change.	Toxicity factor update; update did not change TMCL.	1.0
Volatile Organic Compounds (VOCs)							
71-43-2	Benzene	2.0	No change.	Toxicity factor update; update did not change TMCL.	1.6	USEPA partial approval/disapproval of WA WQS.	1.6
56-23-5	Carbon Tetrachloride	0.46	No change.		0.35	USEPA partial approval/disapproval of WA WQS.	0.35
156-59-2	*cis*- 1,2-Dichloroethene	130	No change.		No change.		130
156-60-5	*trans* -1,2-Dichloroethene	940	No change.		No change.	Federal AWQC and WA WQS updates did not change TMCL.	940
75-35-4	1,1-Dichloroethene	3.2	2,300	Toxicity factor update.	No change.		2300
100-41-4	Ethylbenzene	1.7	No change.		No change.		1.7
91-20-3	Naphthalene	26	No change.		No change.		26
127-18-4	Tetrachloroethene (PCE)	0.021	5.3	Toxicity factor update.	2.9	USEPA partial approval/disapproval of WA WQS.	2.9
108-88-3	Toluene	1300	No change.	Toxicity factor update; update did not change TMCL.	130	USEPA partial approval/disapproval of WA WQS.	130
120-82-1	1,2,4-Trichlorobenzene	0.13	No change.		0.037	USEPA partial approval/disapproval of WA WQS.	0.5
79-01-6	Trichloroethene (TCE)	0.51	1.4	Toxicity factor update.	No change.	Toxicity factor update accounted for in last revision.	0.7
75-01-4	Vinyl Chloride	2.4	No change.		0.18	USEPA partial approval/disapproval of WA WQS.	0.2
Semivolatile Organic Compounds (SVOCs) and Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs)							
117-81-7	bis(2-Ethylhexyl)phthalate	1.2	No change.		0.046	USEPA partial approval/disapproval of WA WQS.	1.0
--	Benzo(a)pyrene TEQ[6]	0.00018	No change.		0.000016	USEPA partial approval/disapproval of WA WQS.	1.0

Table 2-2
Groundwater TMCLs and COPCs

CAS Number	Constituent of Potential Concern[1]	Target Media Cleanup Levels (TMCLs): Original TMCL from Approved 2011 TMCL Tech Memo (µg/L)	Revisions to TMCLs for the 2014 CMS Submittal: Revised TMCL[2,3] (µg/L)	Revisions to TMCLs for the 2014 CMS Submittal: Basis for Change[2,3]	Revisions to TMCLs for the Draft 2017 CMS Submittal: Revised TMCL[3,4] (µg/L)	Revisions to TMCLs for the Draft 2017 CMS Submittal: Basis for Change[3,4]	2017 Proposed FMCL (µg/L)
Polychlorinated Biphenyls (PCBs)							
1336-36-3	Total PCBs[6,7]	0.000023	No change.		0.000007	USEPA partial approval/disapproval of WA WQS.	Note 7
Total Petroleum Hydrocarbons (TPH)[8]							
--	Gasoline-Range TPH (GRPH)	800	No change.	Typographical error in TMCL Tech Memo (correction approved by USEPA 4/4/13).	No change.		BTEXN as surrogate
--	Diesel-Range TPH (DRPH)	500	No change.		No change.		
--	Heavy Oil-Range TPH (ORPH)	500	No change.		No change.		

Notes:

-- Not available.

1 This table includes only those constituents identified as COCs in Tables B.2a through B.2e of the TMCL Technical Memorandum (TMCL Tech Memo; Boeing 2011), with the following exceptions: individual Aroclors were not retained; instead, compliance will be based on attainment of the groundwater TMCL for PCBs (see footnote 7). Benzo(a)pyrene TEQ was not identified as a COC in Table B.2c of the TMCL Tech Memo, but was retained for consideration in the CMS at the request of USEPA.

2 In 2014, the TMCLs were revised to: correct typographic errors, correct errors in calculated values, reflect current IRIS toxicity data, update a bioconcentration factor, and account for the presence of certain metals at naturally-occurring concentrations greater than the previously-developed TMCL.

3 The basis for change(s) in a constituent's TMCL value is briefly described in this table; more detail is provided in Attachment S2A.

4 In 2016 and 2017, the TMCLs were revised to: correct typographic errors, reflect current chemical-specific partitioning factors and toxicity data published in the November 2015 USEPA RSL tables, to incorporate June 2015 Federal AWQC revisions, and to incorporate the November 2016 Washington Clean Water Act-Effective Criteria (40 CFR 131.45).

5 Cobalt was initially retained as a COPC using a drinking water surrogate as the TMCL. Cobalt does not meet the criteria to be considered a soil COC and no surface water or groundwater criteria are available due to insufficient toxicity data. The use of a drinking water exposure as a surrogate standard does not affect the potability designation or the highest beneficial use for groundwater at Plant 2. Thus, the drinking water surrogate has been removed and cobalt is no longer considered a groundwater COPC.

6 An evaluation was performed to ensure the use of summed values for benzo(a)pyrene TEQ, total PCBs, and total xylenes would be protective of exposure to both humans and ecological receptors. Details may be found in Attachment S2A.

7 The proposed FMCL for Total PCBs is the PQL that can be achieved by Boeing's laboratory when performing Total PCB analysis as Aroclors using USEPA Method 8082, which is 0.1 µg/L. The laboratory's method detection limit (MDL) for this method is commonly 0.0094 µg/L. Locations where PCBs are detected at concentrations greater than the MDL will require monitoring for 8 semiannual events, followed by an adaptive management approach to address PCB detections that will be completed in coordination with USEPA. In the future, USEPA will require Boeing to conduct groundwater analysis using a method capable of improved analytical sensitivity (e.g. Method 1668), which will result in a lower PQL and MDL for Total PCBs. This will be conducted in conjunction with an adaptive management approach, and in coordination with the broader LDW CERCLA action and Ecology's water quality permit implementation. USEPA may also require Boeing to conduct analysis for Total PCBs as congeners. For more information, refer to adaptive management text in Volume X of the CMS and Attachment S2D.

8 The highest beneficial use of groundwater at Plant 2 is protection of surface water; in surface water, petroleum is regulated through its constituents. Benzene, ethylbenzene, toluene, xylenes, and naphthalene are the most mobile constituents and will be used to track TPH leaching into groundwater. The TMCLs for these constituents are listed below.

List of TMCLs for TPH Indicator Constituents

TPH Constituents	TMCL (µg/L)[3,4]	Basis for Change
Benzene	1.6	USEPA partial approval/disapproval of WA WQS.
Ethylbenzene	1.7	Federal AWQC and WA WQS updates did not change TMCL.
Toluene	130	USEPA partial approval/disapproval of WA WQS.
Total Xylenes[6]	1,500	Typographic error in October 2014 Draft CMS submittal.
Naphthalene	26	Federal AWQC and WA WQS updates did not change TMCL.

Abbreviations:

AWQC Ambient Water Quality Criteria
BCF Bioconcentration factor
CAS Chemical Abstracts Service
CFR Code of Federal Regulation
CMS Corrective Measure Study
COC Constituent of Concern
COPC Constituent of Potential Concern
FMCL Final Media Cleanup Level
IRIS Integrated Risk Information System
µg/L Micrograms per liter
NA Not applicable
RSL Regional Screening Level
TEQ Toxic equivalent
TMCL Target Media Cleanup Level
WA Washington
WQS Water Quality Standards
USEPA U.S. Environmental Protection Agency

Table 2-3
Groundwater Frequency of Exceedance of Proposed FMCLs by COPCs

Information on Constituents of Potential Concern							Information about Exceedances[1]						
CAS Number	Constituent of Potential Concern[2]	TMCL[3] (µg/L)	Proposed FMCL[4] (µg/L)	Units	Number of Results[1]	Number of Locations[1]	Number of Detected Results Exceeding FMCL	Percent of Detected Results that Exceed FMCL	Number of Locations Exceeding FMCL	Maximum Exceedance Factor[5]	Percent of Locations Exceeding FMCL	Do Locations in the SMWN Exceed?	Comment
Constituents Retained as Groundwater COCs													
Total Metals													
7440-38-2	Arsenic	8.0	8.0	µg/L	940	241	98	10%	42	17	17%	Yes	Soils at background concentrations; groundwater driven by geochemical conditions.
7440-50-8	Copper	8.0	8.0	µg/L	940	241	70	7.4%	29	22	12%	Yes	
Dissolved Metals													
7440-66-6	Zinc	56	56	µg/L	857	248	27	3.2%	14	220	5.6%	Yes	
7440-02-0	Cadmium[6]	0.21	0.21	µg/L	857	248	9	1.1%	7	19	2.8%	Yes	Note 6
7440-48-4	Nickel[7]	8.2	8.2	µg/L	871	248	80	9.2%	27	31	11%	Yes	Note 7
Inorganic Constituents													
57-12-5	Cyanide (free)[8]	1.0	1.0	µg/L	51	51	4	7.8%	4	250	7.8%	No	Note 8
Volatile Organic Compounds (VOCs)													
71-43-2	Benzene	1.6	1.6	µg/L	1,452	257	50	3.4%	12	280	4.7%	Yes	
156-59-2	*cis*- 1,2-Dichloroethene	130	130	µg/L	1,489	257	158	11%	20	170	7.8%	Yes	
100-41-4	Ethylbenzene	1.7	1.7	µg/L	1,452	257	36	2.5%	11	530	4.3%	Yes	
91-20-3	Naphthalene	26	26	µg/L	460	202	8	1.7%	3	24	1.5%	No	Shoreline monitoring well network is in compliance; no upgradient exceedances since 2009.
79-01-6	Trichloroethene (TCE)	0.7	0.7	µg/L	1,489	257	346	23%	64	86,000	25%	Yes	
75-01-4	Vinyl Chloride	0.18	0.2	µg/L	1,489	257	674	45%	128	72,000	50%	Yes	
Polychlorinated Biphenyls (PCBs)													
1336-36-3	Total PCBs[9]	0.000007	0.1	µg/L	113	84	1	0.9%	1	1.6	1.2%	No	
Semivolatile Organic Compounds (SVOCs)													
117-81-7	bis(2-ethylhexyl)phthalate (BEHP)	0.37	1.0	µg/L	98	87	7	7.1%	7	23	8.0%	Yes	Scattered, isolated detections in 2008.
Total Petroleum Hydrocarbons (TPH)[10]													
--	Gasoline-Range TPH (GRPH)	800	Note 10	µg/L	124	78	TMCLs for TPH are based on drinking water; FMCLs are based on protection of surface water. The FMCLs are listed on page 2 for highly mobile constituents of TPH that have regulatory standards (benzene, ethylbenzene, toluene, total xylenes, and naphthalene).						TPH is a COC for groundwater at Plant 2, but will be monitored for compliance using specific constituents with regulatory standards for surface water exposures. The constituents are BTEX and naphthalene.
--	Diesel-Range TPH (DRPH)	500	Note 10	µg/L	123	77							
--	Heavy Oil-Range TPH (ORPH)	500	Note 10	µg/L	123	77							
Constituents Not Retained as Groundwater COCs													
Dissolved Metals													
7440-39-3	Barium	770	770	µg/L	145	145	None	None	None	None	None	No	No exceedances.
7782-49-2	Chromium(VI)[11]	0.58	0.58	µg/L	111	30	1	0.90%	1	21	3.3%	No	A single estimated value in one location in the South Yard.
7440-22-4	Lead	6.1	6.1	µg/L	857	248	None	None	None	None	None	No	No exceedances.
7429-90-5	Selenium	5.0	5.0	µg/L	858	248	13	1.5%	10	64	4.0%	Yes	Selenium exceedances are present only in high salinity wells and were found to be due to a saline matrix interference in the method. Recent data does not exceed.
7439-89-6	Silver	22	22	µg/L	857	248	None	None	None	None	None	No	No exceedances.
7439-96-5	Vanadium	140	140	µg/L	857	248	None	None	None	None	None	No	A single B-Level sample equavalent to the FMCL was previously considered an exceedance; no other exceedances.

Table 2-3
Groundwater Frequency of Exceedance of Proposed FMCLs by COPCs

Information on Constituents of Potential Concern							Information about Exceedances[1]						
CAS Number	Constituent of Potential Concern[2]	TMCL[3] (µg/L)	Proposed FMCL[4] (µg/L)	Units	Number of Results[1]	Number of Locations[1]	Number of Detected Results Exceeding FMCL	Percent of Detected Results that Exceed FMCL	Number of Locations Exceeding FMCL	Maximum Exceedance Factor[5]	Percent of Locations Exceeding FMCL	Do Locations in the SMWN Exceed?	Comment
Constituents Not Retained as Groundwater COCs (continued)													
Volatile Organic Compounds (VOCs)													
56-23-5	Carbon Tetrachloride	0.35	0.35	µg/L	1,452	257	10	0.69%	2	3.7	0.78%	Yes	Shoreline monitoring well network has been in compliance since 2007; other location a one-time only hit in 2008.
156-60-5	*trans* -1,2-Dichloroethene	940	940	µg/L	1,489	257	None	None	None	None	None	No	No exceedances.
75-35-4	1,1-Dichloroethene	2,300	2,300	µg/L	1,452	257	None	None	None	None	None	No	No exceedances.
127-18-4	Tetrachloroethene (PCE)	2.9	2.9	µg/L	1,446	257	17	1.2%	5	2.3	2.0%	No	No exceedances in recent years, after completion of interim measures; older exceedances minor.
108-88-3	Toluene	130	130	µg/L	1,452	257	3	0.21%	2	2.4	0.78%	Yes	No recent exceedances at either location (8 events and 20 events, respectively); older exceedances minor.
120-82-1	1,2,4-Trichlorobenzene	0.037	0.6	µg/L	460	202	None	None	None	None	None	No	No exceedances.
Semivolatile Organic Compounds (SVOCs)													
--	Benzo(a)pyrene TEQ[9]	0.000016	1.0	µg/L	122	87	None	None	None	None	None	No	No exceedances.

Notes:

-- Not available.

1 Number of results and exceedance information is based on groundwater data collected between January 1, 2005, and August 28, 2013. In some areas of Plant 2, more recent groundwater data reflecting newer analytical methods or post-interim action conditions have been collected and analyzed; more recent data was not used to identify Plant 2 COCs, but is shown on figures and discussed in later sections of Volume X of the Corrective Measures Study (CMS).

2 Constituents of potential concern included in this table are those identified in Table 2-2, which were derived in the 2011 TMCL Tech Memo (Boeing 2011).

3 The TMCLs in this table were revised by The Boeing Company in 2016 and 2017 from the originals to account for updated toxicity factors, newly promulgated surface water criteria, and other information. Original and revised TMCLs are presented in Table 2-2.

4 Proposed FMCLs are equal to the TMCLs except where the TMCLs are less than the PQLs, in which case PQLs are proposed as FMCLs. Because the groundwater TMCLs are based on surface water criteria, proposed FMCLs are generally from Washington State Department of Ecology's 2011 Water Quality Permit Writer's Manual, which defines the PQL that must be met for compliance with standards derived under the CWA. For more information, refer to Attachment S2D.

5 The exceedance factor is the maximum concentration divided by the criterion, expressed as a fraction; values greater than 1 occur when there is an exceedance. Slight deviations in the "number of exceedances" column of this table may be present relative to the October 2014 Draft CMS. In that version of the report, results equal to the TMCL were identified as exceedances. Exceedance factors are rounded to two significant figures.

6 The PQL for the method used for the vast majority of historical cadmium groundwater analysis at Plant 2 is greater than the revised TMCL. More recent data collected and analyzed for cadmium with a more sensitive analytical method may be subject to a saline matrix interference: the only locations with exceedances of the cadmium FMCL are in the shoreline, where salinity is greater. Cadmium is a pending groundwater COC, and may be subject to the adaptive management approach for inorganics. Refer to the text of Volume X of the CMS for more details.

7 Nickel groundwater data show a strong salinity interference in brackish and saline samples. Recently collected data analyzed using a USEPA-approved modification to the laboratory method eliminated nickel as a COC at all locations except for PL2-621A.

8 The method approved in historical sampling plans (SM4500CN-I: WAD equivalent analysis) is neither consistent with nor equivalent to the method used to establish the TMCL and FMCL. Cyanide is retained as a pending groundwater COC at four locations (PL2-615A, PL2-619A, and PL2-619B), closely cross-gradient and downgradient of areas where weak acid dissociable (WAD) cyanide was detected at concentrations greater than the FMCL in data gaps investigations. This COC may be eliminated based on future data using the correct method for the standard.

9 An evaluation was performed to ensure the use of summed values for benzo(a)pyrene TEQ, total PCBs, and total xylenes would be protective of exposure to both humans and ecological receptors. Details may be found in Attachment S2A.

10 The highest beneficial use of groundwater at Plant 2 is protection of surface water; in surface water, petroleum is regulated through its constituents. Benzene, ethylbenzene, toluene, xylenes, and naphthalene are the most mobile constituents and will be used to track TPH leaching into groundwater. The TMCLs and proposed FMCLs are listed below.

List of TMCLs and Proposed FMCLs for TPH Indicator Constituents

TPH Constituents	TMCL (µg/L)[2]	Proposed FMCL (µg/L)[3]
Benzene	2.0	2.0
Ethylbenzene	1.7	1.7
Toluene	520	520
Total Xylenes[9]	1,500	1,500
Naphthalene	26	26

11 The only exceedance of the chromium(VI) criterion is a result that was J qualified, for "estimated quantity." The total chromium result collected during the same event was non-detect at a reporting limit of 5 µg/L, indicating that this result is likely to be spurious.

Abbreviations:

CAS Chemical Abstracts Service
CMS Corrective Measures Study
COC Constituent of Concern
CWA Clean Water Act
FMCL Final Media Cleanup Level
µg/L Micrograms per liter
PQL Practical Quantitation Limit
SMWN Shoreline Monitoring Well Network
TMCL Target Media Cleanup Level
TEQ Toxic equivalent
USEPA U.S. Environmental Protection Agency

Table 2-4
Groundwater FMCLs and COCs[1]

CAS Number	Groundwater Constituent of Concern	Proposed FMCL[2]	Units	Percent of Locations Exceeding FMCL	Are There Exceedances in the SMWN?	Comment
Metals and Inorganics						
7440-38-2	Arsenic, total	8.0	µg/L	17%	Yes	
7440-50-8	Copper, total	8.0	µg/L	12%	Yes	
7440-66-6	Zinc, dissolved	56	µg/L	5.7%	Yes	
7440-02-0	Cadmium, dissolved	0.21	µg/L	2.8%	Yes	Pending COC; see text.
7440-48-4	Nickel, dissolved	8.2	µg/L	11%	Yes	Pending COC at well PL2-621A only; see text.
57-12-5	Cyanide (free)	1.0	µg/L	7.8%	Yes	Pending COC; see text.
Volatile Organic Compounds (VOCs)						
71-43-2	Benzene	1.6	µg/L	4.7%	Yes	
156-59-2	*cis*- 1,2-Dichloroethene	130	µg/L	7.8%	Yes	
100-41-4	Ethylbenzene	1.7	µg/L	4.3%	Yes	
91-20-3	Naphthalene	26	µg/L	1.5%	No	
79-01-6	Trichloroethene (TCE)	0.70	µg/L	25%	Yes	
75-01-4	Vinyl Chloride	0.20	µg/L	50%	Yes	
Polychlorinated Biphenyls (PCBs) and Semivolatile Organic Compounds						
1336-36-3	Total PCBs[3]	0.10	µg/L	1.2%	Yes	Isolated locations.
117-81-7	bis(2-ethylhexyl)phthalate	1.0	µg/L	8.1%	Yes	Pending COC; see text.
Petroleum Hydrocarbon Constituents						
71-43-2	Benzene	1.6	µg/L	4.7%	Yes	These mobile constituents of petroleum products have existing regulatory surface water standards and will be used as a surrogate for TPH.
100-41-4	Ethylbenzene	1.7	µg/L	4.3%	Yes	
108-88-3	Toluene	130	µg/L	0.78%	Yes	
1330-20-7	Total Xylenes[3]	1,500	µg/L	0%	No	
91-20-3	Naphthalene	26	µg/L	1.5%	No	

Note:

1 This table is a summary of information presented in Table 2-3. Exceedance information is based on groundwater data collected between January 1, 2005, and August 28, 2013. In some areas of Plant 2, more recent groundwater data reflecting newer analytical methods or post-interim action conditions have been collected and analyzed. These data were not used to identify Plant 2 COCs, but are shown on figures and discussed in later sections of Volume X of the Corrective Measures Study.

2 Proposed FMCLs are equal to the TMCLs except where the TMCLs are less than the PQLs, in which case PQLs are proposed as FMCLs. For more information, refer to Attachment S2D.

3 An evaluation was performed to ensure the use of summed values for benzo(a)pyrene TEQ, total PCBs, and total xylenes would be protective of exposure to both humans and ecological receptors. Details may be found in Attachment S2A.

Abbreviations:

CAS Chemical Abstracts Service
COC Constituent of Concern
FMCL Final Media Cleanup Standard
µg/L Micrograms per liter
PQL Practical Quantitation Limit
SMWN Shoreline Monitoring Well Network
TEQ Toxic equivalent
TMCL Target Media Cleanup Level
TPH Total petroleum hydrocarbons

Table 2-5
Soil TMCLs, COPCs, and Proposed FMCLs

CAS Number	Constituent of Potential Concern[1]	Target Media Cleanup Levels (TMCLs) (derived from the lesser of the leaching and residential direct contact screening levels): Original TMCL from Approved 2011 TMCL Tech Memo (mg/kg)	Revisions to TMCLs for the 2014 CMS Submittal: Revised TMCLs[2] (mg/kg)	Revisions to TMCLs for the 2014 CMS Submittal: Basis for Change[2]	Revisions to TMCLs for the 2017 CMS Submittal: Revised TMCLs[3] (mg/kg)	Revisions to TMCLs for the 2017 CMS Submittal: Basis for Change[3]	Pathway on which the Revised TMCL is based	Screening Level Leaching to Groundwater: Modeled Leaching Component of the TMCL (soil to protect GW)[3,4] (mg/kg)	Proposed FMCLs: Unpaved Shoreline: Lowest Residential Component of the TMCL (direct contact)[3,5] (mg/kg)	Proposed FMCLs: Paved Industrial: Industrial Component of the TMCL (direct contact)[3,6] (mg/kg)
Metals										
7440-36-0	Antimony	31	No change.		No change.		Residential	750	31	410
7440-38-2	Arsenic	20	No change.		No change.		Background	20	20	88
7440-39-3	Barium	100	680	BCF correction.	640	Transcription error in CMS table.	Leaching	640	15,000	190,000
7440-43-9	Cadmium	4	8.9	Hardness correction.	3.3	Toxicity factor update.	Leaching	3.3	70	800
18540-29-9	Chromium (VI)	1.2	No change.		No change.	Toxicity factor/absorption fraction updated; but no change to TMCL.	Residential	--	1.2	56
7440-48-4	Cobalt	12	23	Removal of drinking water surrogate.	No change.		Residential	--	23	300
7440-50-8	Copper	80	No change.		No change.		Leaching	80	3,100	41,000
7439-92-1	Lead	250	No change.		No change.		Residential	1,900	250	800
7439-97-6	Mercury as Elemental Mercury[7]	1.5	No change.		No change.	Toxicity factor updated; but no change to TMCL.	Leaching	1.5	11	46
7487-94-7	Mercury as Inorganic Mercury Salts[7]	23	No change.		No change.		Residential	--	23	310
7439-98-7	Molybdenum	20	No change.		No change.		Leaching	20	390	5,100
7440-02-0	Nickel	210	No change.		No change.		Leaching	210	1,500	20,000
7782-49-2	Selenium	1.0	No change.		No change.		Leaching	1	390	5,100
7440-66-6	Zinc	1,400	2,100	Hardness correction.	1,400	Error in earlier CMS table; hardness correction should not have impacted soil TMCL.	Leaching	1,400	23,000	310,000
Other Inorganics										
57-12-5	Cyanide (free)	20	No change.	Toxicity factor updated; but no change to TMCL.	2.7	Toxicity factor update.	Residential	20	2.7	12
Volatile Organic Constituents (VOCs) not including pre-2005 data										
71-43-2	Benzene	0.093	No change.	Toxicity factor updated; but no change to TMCL.	No change.		Leaching	0.093	1.0	50
75-34-3	1,1-Dichloroethane	0.71	No change.		No change.		Leaching	0.71	3.1	150
75-35-4	1,1-Dichloroethene	0.081	59	Toxicity factor update.	No change.		Leaching	59	230	1,000
156-59-2	*cis*- 1,2-Dichloroethene	2.6	No change.		No change.		Leaching	2.6	160	2,000
100-41-4	Ethylbenzene	0.23	No change.		No change.		Leaching	0.23	5.0	250
75-09-2	Methylene Chloride	0.65	1.9	Toxicity factor update.	1.0	Federal AWQC update.	Leaching	1.0	56	3,000
91-20-3	Naphthalene	3.6	No change.		No change.		Residential	16	3.3	170
79-34-5	1,1,2,2-Tetrachloroethane	0.013	No change.		No change.		Leaching	0.013	0.53	26
127-18-4	Tetrachloroethene (PCE)	0.0016	0.25	Toxicity factor update.	0.41	Federal AWQC update.	Leaching	0.41	21	390
108-88-3	Toluene	100	No change.		41	Federal AWQC update.	Leaching	41	4,900	44,000
79-00-5	1,1,2-Trichloroethane	0.073	No change.		No change.	Toxicity factor updated; but no change to TMCL.	Leaching	0.073	1.0	6.3

Table 2-5
Soil TMCLs, COPCs, and Proposed FMCLs

CAS Number	Constituent of Potential Concern[1]	Target Media Cleanup Levels (TMCLs) (derived from the lesser of the leaching and residential direct contact screening levels): Original TMCL from Approved 2011 TMCL Tech Memo (mg/kg)	Revisions to TMCLs for the 2014 CMS Submittal: Revised TMCLs[2] (mg/kg)	Revisions to TMCLs for the 2014 CMS Submittal: Basis for Change[2]	Revisions to TMCLs for the 2017 CMS Submittal: Revised TMCLs[3] (mg/kg)	Revisions to TMCLs for the 2017 CMS Submittal: Basis for Change[3]	Pathway on which the Revised TMCL is based	Screening Level: Leaching to Groundwater: Modeled Leaching Component of the TMCL (soil to protect GW)[3,4] (mg/kg)	Proposed FMCLs: Unpaved Shoreline: Lowest Residential Component of the TMCL (direct contact)[3,5] (mg/kg)	Proposed FMCLs: Paved Industrial: Industrial Component of the TMCL (direct contact)[3,6] (mg/kg)
Volatile Organic Constituents (VOCs) not including pre-2005 data (continued)										
79-01-6	Trichloroethene (TCE)[8]	0.018	0.051	Toxicity factor update.	No change.	Toxicity factor updated; but no change to TMCL.	Leaching	0.051	0.92	19
120-82-1	1,2,4-Trichlorobenzene	0.08	No change.		0.046	Federal AWQC update.	Leaching	0.046	22	260
75-01-4	Vinyl Chloride	0.000081	0.034	Toxicity factor update.	0.022	Federal AWQC update.	Leaching	0.022	0.06	16
1330-20-7	Xylenes (total)[9,10]	200	No change.		No change.		Leaching	200	580	2,500
Semivolatile Organic Compounds (SVOCs)										
117-81-7	bis(2-ethylhexyl)phthalate	35	No change.		17	Federal AWQC update.	Leaching	17	35	1,200
7440-62-2	1-Methylnaphthalene	16	No change.		No change.		Residential	--	16	530
129-00-0	Pyrene	240	No change.		No change.		Leaching	240	1,700	17,000
Mutagenic Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs)										
--	Benzo(a)pyrene TEQ[10,11,12]	0.015	0.14	Modified background.	No change.		Residential	0.057	0.14	2.1
Polychlorinated Biphenyls (PCBs)										
1336-36-3	Total PCBs[9]	0.0018	No change.		No change.	Toxicity factor updated; but no change to TMCL.	Leaching	0.0018	0.20	10
Total Petroleum Hydrocarbons (TPH)[13]										
--	Gasoline-Range TPH (GRPH)	30	No change.		No change.		Residential	30	30	7,500
--	Diesel-Range TPH (DRPH)	2,000	No change.		No change.		Residential	2,000	2,000	17,000
--	Heavy Oil-Range TPH (ORPH)	2,000	No change.		No change.		Residential	2,000	2,000	17,000

Notes:

-- Not available.

1 This table includes only those constituents identified as COCs in Tables B.1a through B.1e of the TMCL Tech Memo (Boeing 2011). Iron and manganese are not included in this table. The only soil source area in OA-1/OA-2 was removed in an interim measure (Interim Measure Completion Report: Duct Bank Line in the 2-31/2-40s/2-66 Areas; Golder 2011) and remaining soil concentrations are below both natural background concentrations and their USEPA TMCLs. Iron and manganese are no longer considered groundwater COPCs (Section 1.4.4.6), so the leaching pathway is not of concern.

2 The TMCLs were revised to: correct typographic errors, correct errors in calculated values, reflect current IRIS toxicity data, utilize a more appropriate bioconcentration factor, and account for the presence of certain metals at naturally-occurring concentrations greater than the previously-developed TMCL. The basis for the change in TMCL value is briefly described in this table, and is described in more detail in Appendix S2A of the CMS.

3 In December 2015, the TMCLs for COPCs were revised to reflect current chemical-specific partitioning factors and toxicity data published in the November 2015 USEPA RSL tables, to incorporate June 2015 Federal AWQC revisions, and to correct typographic errors. Though the Basis for Change listed in this table is specific to the factor(s) driving revisions to the Revised TMCLs, updated partitioning factors and toxicity factors also impact the calculation of soil screening levels and proposed FMCLs. Soil screening levels and FMCLs have also been updated to reflect the changes previously described in conjunction with revision

4 This pathway represents the calculated soil concentration that is protective of groundwater using the three-phase model and the assumptions indicated in the TMCL Tech Memo. The groundwater concentrations that these soil concentrations are protective of are revised TMCLs for groundwater (see note 2, above; numeric values are provided in Table 2-2).

5 This pathway represents the lesser of the two residential pathways established in the TMCL Tech Memo, after consideration of background soil concentrations. The two residential criteria values considered are the USEPA RSL including ingestion, dermal, and inhalation pathways, and the MTCA Method B unrestricted land use cleanup level.

6 This pathway represents the lesser of the industrial pathways established in the TMCL Tech Memo, after consideration of background soil concentrations. The industrial criteria values considered are the USEPA RSL including ingestion, dermal, and inhalation pathways, and the MTCA Method C industrial land use cleanup level. An exception was made for Total PCBs: the Proposed FMCL is set at the threshold for requiring a TSCA cap for High Occupancy Areas. As the industrial area is paved or covered in buildings, exposure assumptions implicit in the USEPA RSL calculations have been modified to a 1 in 100,000 excess individual lifetime cancer risk and soil ingestion rate of 100 milligram per day (applied when pavement is present) by a USEPA Region 10 risk management decision.

7 Both forms of mercury were retained as COCs in Appendix B of the TMCL Tech Memo; however, the specific form in soil was not specified. The lower of the two mercury criteria will be used to determine compliance.

8 TMCLs and Proposed FMCLs developed for this constituent include consideration of a chemical-specific short-term exposure pathway for women of reproductive age. This pathway was not selected as the Proposed FMCL or TMCL, as other pathways resulted in more conservative criteria.

9 Older data are reported as total xylenes, whereas newer data are reported as o-xylene and m,p-xylene. Some areas with total data do not have more recent isomer-specific data.

10 An evaluation was performed to ensure the use of summed values for benzo(a)pyrene TEQ, total PCBs, and total xylenes would be protective of exposure to both humans and ecological receptors. Details may be found in Attachment S2A.

11 Benzo(a)pyrene TEQ calculated using one-half the reporting limit as a surrogate for non-detected constituents when at least one constituent contributing to the TEQ was detected.

12 USEPA has approved the use of the Washington State Department of Ecology's Toxic Equivalency Factors for this site.

13 Petroleum hydrocarbons have been measured at Boeing Plant 2 over the years using a variety of methods and standards. Refer to Section 2.3.1 for a summary of the relationships between the results of various methods and the available standards used to form the TMCLs and FMCLs.

Abbreviations:

AWQC Ambient Water Quality Criteria
BCF Bioconcentration Factor
CAS Chemical abstract system
CMS Corrective Measures Study
COC Constituent of concern
COPC Constituent of potential concern
FMCL Final Media Cleanup Level
GW Groundwater
IRIS Integrated Risk Information System
mg/kg Milligram per kilogra,
MTCA Model Toxics Control Act
RSL Regional Screening Level
TEQ Toxic equivalent
TSCA Toxic Substances Control Act
USEPA U.S. Environmental Protection Agency

Table 2-6
Soil Frequency of Exceedances of Proposed FMCLs in the Paved Industrial Area

Information on COPC			Information About Detected Results[1]					Information About Exceedances[1]								
								Residential Direct Contact Component of TMCL				Proposed Industrial FMCL (Direct Contact)				
CAS Number	Constituent of Potential Concern[2]	Units	Number of Results	Number of Detected Results	Percent of Detected Results	Minimum Detected Value	Maximum Detected Value	Residential Direct Contact Component of TMCL[3]	Number of Detected Results that Exceed Residential MCL	Percent of Detected Results that Exceed Residential MCL	Exceedance Factor[4,5]	Proposed Industrial FMCL[6]	Number of Detected Results that Exceed Industrial MCL	Percent of Detected Results that Exceed Industrial MCL	Exceedance Factor[4]	Comment (see note 7 for criteria establishing COC status)
Soil COCs Based on Direct Contact Criteria in the Paved Industrial Area at Plant 2																
Metals and Inorganics																
57-12-5	Cyanide (free)	mg/kg	723	164	22%	0.051	4,600	2.7	18	2.5%	1,700	12	7	1.0%	380	Only 2 of 723 exceedances; but exceedance factor > 10.
Organic Compounds																
--	Benzo(a)pyrene TEQ[8]	mg/kg	879	307	35%	0.000021	270	0.14	51	5.8%	1,900	2.1	14	1.6%	130	Soil COC.
1336-36-3	Total PCBs[8]	mg/kg	1,307	251	19%	0.0094	660	0.20	105	8.0%	3,300	10	9	0.69%	70	Soil COC.
--	Gasoline-Range TPH (GRPH)[8]	mg/kg	626	58	9.3%	6.4	18,000	30	21	3.4%	600	7,500	2	0.32%	2.4	COC for direct contact and/or potential free product.
--	Diesel-Range TPH (DRPH)[9]	mg/kg	1,303	470	36%	2	56,827	2,000	43	3.3%	28	17,000	8	0.61%	3.3	COC for direct contact and/or potential free product.
--	Heavy Oil-Range TPH (ORPH)	mg/kg	1,016	398	39%	5.4	96,000	2,000	15	1.5%	48	17,000	4	0.39%	5.6	COC for direct contact and/or potential free product.
Soil Constituents Not Retained as COCs Based on Direct Contact Criteria in the Paved Industrial Area at Plant 2																
Metals and Inorganics																
7440-36-0	Antimony	mg/kg	1,701	34	2.0%	0.1	12	31	None	None	None	410	None	None	None	No direct contact exceedances.
7440-38-2	Arsenic	mg/kg	1,925	759	39%	0.1	288	20	4	0.21%	14	88	1	0.05%	3.3	Only 1 exceedance of almost 2,000 samples; exceedance factor of 3.3.
7440-39-3	Barium	mg/kg	1,600	1,600	100%	9.6	2,890	15,000	None	None	None	190,000	None	None	None	No direct contact exceedances.
7440-43-9	Cadmium	mg/kg	1,945	419	22%	0.133	255	70	2	0.10%	4	800	None	None	None	No FMCL exceedances.
18540-29-9	Chromium(VI)	mg/kg	138	13	9.4%	0.21	160	1.2	3	2.17%	130	56	1	0.72%	2.9	Only 1 of 140 samples exceed industrial direct contact; exceedance factor of 2.9.
7440-48-4	Cobalt	mg/kg	1,430	1,429	100%	0.7	74	23	8	0.56%	3.2	300	None	None	None	No FMCL exceedances.
7440-50-8	Copper	mg/kg	1,886	1,886	100%	0.3	3,830	3,100	1	0.05%	1.2	41,000	None	None	None	No FMCL exceedances.
7439-92-1	Lead	mg/kg	1,949	1,538	79%	0.917	3,150	250	4	0.21%	13	800	1	0.05%	3.9	1 exceedance of almost 2,000 samples; exceedance factor of 3.9.
7439-97-6	Mercury, Elemental	mg/kg	1,890	560	30%	0.02	38	11	2	0.11%	3.5	46	None	None	None	No FMCL exceedances.
7439-98-7	Molybdenum	mg/kg	984	392	40%	0.126	30	390	None	None	None	5,100	None	None	None	No direct contact exceedances.
7440-02-0	Nickel	mg/kg	1,845	1,844	100%	3	130	1,500	None	None	None	20,000	None	None	None	No direct contact exceedances.
7782-49-2	Selenium	mg/kg	1,857	54	3%	0.1	9	390	None	None	None	5,100	None	None	None	No direct contact exceedances.
7440-66-6	Zinc	mg/kg	1,895	1,895	100%	5	3,070	23,000	None	None	None	310,000	None	None	None	No direct contact exceedances.
Volatile Organic Constituents (VOCs)																
71-43-2	Benzene	mg/kg	1,187	164	14%	0.0007	0.73	1.0	None	None	None	50	None	None	None	No direct contact exceedances.
75-34-3	1,1-Dichloroethane	mg/kg	1,180	5	0.4%	0.0018	0.0061	3.1	None	None	None	150	None	None	None	No direct contact exceedances.
75-35-4	1,1-Dichloroethene	mg/kg	1,180	None	None		None	230	None	None	None	1,000	None	None	None	No direct contact exceedances.
156-59-2	*cis* -1,2-Dichloroethene	mg/kg	1,181	86	7%	0.0011	16	160	None	None	None	2,000	None	None	None	No direct contact exceedances.
100-41-4	Ethylbenzene	mg/kg	1,187	12	1%	0.0017	0.47	5.0	None	None	None	250	None	None	None	No direct contact exceedances.
75-09-2	Methylene Chloride	mg/kg	1,180	116	10%	0.0015	0.017	56	None	None	None	3,000	None	None	None	No direct contact exceedances.

Table 2-6
Soil Frequency of Exceedances of Proposed FMCLs in the Paved Industrial Area

Information on COPC			Information About Detected Results[1]					Information About Exceedances[1]								
								Residential Direct Contact Component of TMCL				Proposed Industrial FMCL (Direct Contact)				
CAS Number	Constituent of Potential Concern[2]	Units	Number of Results	Number of Detected Results	Percent of Detected Results	Minimum Detected Value	Maximum Detected Value	Residential Direct Contact Component of TMCL[3]	Number of Detected Results that Exceed Residential MCL	Percent of Detected Results that Exceed Residential MCL	Exceedance Factor[4,5]	Proposed Industrial FMCL[6]	Number of Detected Results that Exceed Industrial MCL	Percent of Detected Results that Exceed Industrial MCL	Exceedance Factor[4]	Comment (see note 7 for criteria establishing COC status)
Soil Constituents Not Retained as COCs Based on Direct Contact Criteria in the Paved Industrial Area at Plant 2 (continued)																
Volatile Organic Constituents (VOCs) (continued)																
91-20-3	Naphthalene[10]	mg/kg	1,639	148	9%	0.0024	520	3.3	13	0.79%	160	170	2	0.12%	3.1	2 exceedances of almost 1,600 samples; exceedance factor is 3.1. Exceedances are from the 1990s; the absence of more recent exceedances indicates it is no longer an issue.
79-34-5	1,1,2,2-Tetrachloroethane	mg/kg	1,180	None	None	None	None	0.53	None	None	None	26	None	None	None	No direct contact exceedances.
127-18-4	Tetrachloroethene (PCE)	mg/kg	1,180	50	4%	0.0011	0.41	21	None	None	None	390	None	None	None	No direct contact exceedances.
108-88-3	Toluene	mg/kg	1,187	76	6%	0.001	0.84	4,900	None	None	None	44,000	None	None	None	No direct contact exceedances.
79-00-5	1,1,2-Trichloroethane	mg/kg	1,180	4	0.34%	0.0012	0.0046	1.0	None	None	None	6.3	None	None	None	No direct contact exceedances.
79-01-6	Trichloroethene (TCE)	mg/kg	1,181	310	26%	0.0009	47	0.92	10	0.85%	51	19	1	0.08%	2.5	1 exceedance of almost 1,200 samples; exceedance factor is 2.6.
120-82-1	1,2,4-Trichlorobenzene	mg/kg	1,557	3	0.19%	0.07	0.31	22	None	None	None	260	None	None	None	No direct contact exceedances.
75-01-4	Vinyl Chloride	mg/kg	1,180	23	2%	0.0015	0.015	0.06	None	None	None	16	None	None	None	No direct contact exceedances.
1330-20-7	Total Xylenes[8]	mg/kg	1,187	29	2%	0.0019	2.7022	580	None	None	None	2,500	None	None	None	No direct contact exceedances.
Semivolatile Organic Compounds (SVOCs)																
117-81-7	bis(2-ethylhexyl)phthalate	mg/kg	789	113	14%	0.0081	330	35	1	0.13%	9.4	1,200	None	None	None	No FMCL exceedances.
7440-62-2	1-Methylnaphthalene	mg/kg	305	77	25%	0.0024	150	16	1	0.33%	9.4	530	None	None	None	No FMCL exceedances.
129-00-0	Pyrene	mg/kg	856	320	37%	0.0018	550	1,700	None	None	None	17,000	None	None	None	No direct contact exceedances.

Notes:

-- Not available.

1 Number of results and exceedance information for VOCs are based on soil data collected between January 1, 2005, and July 17, 2013; for all other analyte classes these are based on soil data collected prior to July 17, 2013. In some areas of Plant 2, more recent soil data reflecting post-interim action conditions have been collected and analyzed. More recent data is shown on figures and discussed in later sections of Volume X of the Corrective Measures Study as appropriate, but was not used to identify Plant 2 COCs.

2 COPCs included in this table are those identified in Table 2-5, which were derived in the 2011 TMCL Tech Memo (Boeing 2011).

3 Residential Direct Contact Component of TMCL from Table 2-5 (Residential MCL). The Residential MCL was included to give readers a sense of how much residual contamination would remain at Plant 2 after remediation to meet the Proposed Industrial FMCLs was completed. Residual contamination for two COCs (Total PCBs and benzo(a)pyrene TEQ) exceed in 5 to 7% of the remaining samples in the industrial area, while the remaining COCs exceed the Residential MCL in 1 to 4% of site-wide samples. However, cleanup to the Residential MCL is hampered by the fact that remaining exceedances are spatially distributed throughout the site at variable depths with no clear source area or easily accessible hot spots.

4 The exceedance factor is the maximum concentration divided by the criterion, expressed as a fraction; values greater than 1 occur when there is an exceedance. Exceedance factors are rounded to two significant digits.

5 Maintenance of pavement is not required for contamination remaining on-site that exceeds the Residential MCL after remediation. However, where the soil criteria presented in footnote 6b or 6c are exceeded for the Residential MCL, residential use will be prohibited in a restrictive environmental covenant.

6 The proposed Industrial FMCL for the paved industrial area is presented in Table 2-5.

7 The following criteria were used to identify COCs:

a. If the exceedance factor was ≤ 2 and percent exceeding was ≤ 10%, the constituent was eliminated as a COC in accordance with MTCA soil compliance rules for screening constituents in soil found in WAC 173-340-740(7)(e)(i-ii); the use of these rules was approved by USEPA.

b. If exceedance factor was > 10, even a single isolated sample would cause the constituent to be retained as a COC.

c. If maximum exceedance factor was between 2 and 10 AND the number of samples with exceedances was less than 0.1% (1 in 1,000), the constituent was not considered a COC. In the Paved Industrial Area, constituent-specific exceptions were made for naphthalene and chromium(VI), as described in the comment field.

8 An evaluation was performed to ensure the use of summed values for benzo(a)pyrene TEQ, total PCBs, and total xylenes would be protective of exposure to both humans and ecological receptors. Details may be found in Attachment S2A.

9 The October 2014 Draft CMS erroneously included kerosene results in the results for GRPH, rather than in the results for DRPH; this error has been corrected, and information about detections and exceedances have changed from the previous version of the table as a result.

10 Napthalene can be analyzed by both SVOC and VOC methods. The TMCL Tech Memo (Boeing 2011) includes naphthalene in both the VOC and SVOC constituent classes. Therefore, samples pre-dating 2005 were not excluded from the dataset for naphthalene, unlike for other VOCs. To simplify CMS Report tables, naphthalene is included only in the VOC constituent class.

Abbreviations:

CAS Chemical Abstract System
COC Constituent of Concern
COPC Constituent of Potential Concern
FMCL Final Media Cleanup Level
MCL Media Cleanup Level
mg/kg Milligrams per kilogram
MTCA Model Toxics Control Act
PCB Polychlorinated biphenyls
TEQ Toxic equivalent
TMCL Target Media Cleanup Level
USEPA U.S. Environmental Protection Agency
WAC Washington Administrative Code

Table 2-7
Soil Frequency of Exceedances of Proposed FMCLs in the Unpaved Shoreline Area

Information on COPC			Information about Detected Results[1]					Information About Exceedances[1] Proposed Shoreline FMCL (Residential Direct Contact)				COC Outcome
CAS Number	Constituent of Potential Concern[2]	Units	Number of Results	Number of Detected Results	Percent of Detected Results	Minimum Detected Value	Maximum Detected Value	Residential Direct Contact Component of TMCL[3]	Number of Detected Results that Exceed Residential MCL	Percent of Detected Results that Exceed Residential MCL	Exceedance Factor[4]	Comment (see note 5 for criteria establishing COC status)
Soil COCs Based on Direct Contact Criteria in the Unpaved Shoreline Area at Plant 2												
Total Petroleum Hydrocarbons (TPH)												
--	Heavy Oil-Range TPH (ORPH)	mg/kg	43	19	44%	11	59,000	2,000	2	4.7%	30	COC for Shoreline for direct contact; 2 locations exceed but exceedance factor > 10.
Soil Constituents Not Retained as COCs Based on Direct Contact in the Unpaved Shoreline Area at Plant 2												
Metals												
7440-36-0	Antimony	mg/kg	20	None	None	None	None	31	None	None	None	No residential exceedances.
7440-38-2	Arsenic	mg/kg	22	12	55%	1.7	11	20	None	None	None	No residential exceedances.
7440-39-3	Barium	mg/kg	22	22	100%	20.9	96	15,000	None	None	None	No residential exceedances.
7440-43-9	Cadmium	mg/kg	22	6	27%	0.2	3	70	None	None	None	No residential exceedances.
18540-29-9	Chromium(VI)	mg/kg	None	None	None	None	None	1.2	None	None	None	No residential exceedances.
7440-48-4	Cobalt	mg/kg	20	20	100%	3.1	10	23	None	None	None	No residential exceedances.
7440-50-8	Copper	mg/kg	20	20	100%	9.5	28	3,100	None	None	None	No residential exceedances.
7439-92-1	Lead	mg/kg	22	17	77%	3	184	250	None	None	None	No residential exceedances.
7439-97-6	Mercury as Elemental	mg/kg	22	11	50%	0.03	0.39	11	None	None	None	No residential exceedances.
7439-98-7	Molybdenum	mg/kg	18	15	83%	0.378	6	390	None	None	None	No residential exceedances.
7440-02-0	Nickel	mg/kg	20	20	100%	6.43	38	1,500	None	None	None	No residential exceedances.
7782-49-2	Selenium	mg/kg	22	None	None	None	None	390	None	None	None	No residential exceedances.
7440-66-6	Zinc	mg/kg	20	20	100%	20	86	23,000	None	None	None	No residential exceedances.
Other Inorganics												
57-12-5	Cyanide (free)	mg/kg	14	2	14%	0.059	0.147	2.7	None	None	None	No residential exceedances.
Volatile Organic Constituents (VOCs)												
71-43-2	Benzene	mg/kg	28	6	21%	0.0006	0.0092	1.0	None	None	None	No residential exceedances.
75-34-3	1,1-Dichloroethane	mg/kg	28	None	None	None	None	3.1	None	None	None	No residential exceedances.
75-35-4	1,1-Dichloroethene	mg/kg	28	None	None	None	None	230	None	None	None	No residential exceedances.
156-59-2	*cis*- 1,2-Dichloroethene	mg/kg	28	3	11%	0.0049	140	160	None	None	None	No residential exceedances.
100-41-4	Ethylbenzene	mg/kg	28	None	None	None	None	5.0	None	None	None	No residential exceedances.
75-09-2	Methylene Chloride	mg/kg	28	6	21%	0.0026	0.006	56	None	None	None	No residential exceedances.
91-20-3	Naphthalene	mg/kg	30	4	13%	0.006	0.096	3.3	None	None	None	No residential exceedances.
79-34-5	1,1,2,2-Tetrachloroethane	mg/kg	28	None	None	None	None	0.53	None	None	None	No residential exceedances.
127-18-4	Tetrachloroethene (PCE)	mg/kg	28	None	None	None	None	21	None	None	None	No residential exceedances.
108-88-3	Toluene	mg/kg	28	5	18%	0.0006	0.0049	4,900	None	None	None	No residential exceedances.
79-00-5	1,1,2-Trichloroethane	mg/kg	28	None	None	None	None	1.0	None	None	None	No residential exceedances.
79-01-6	Trichloroethene (TCE)	mg/kg	28	5	18%	0.0022	2.4	0.92	1	3.6%	2.6	1 location with an exceedance factor of 2.6 at depth of 11 feet bgs; not retained as a COC for direct contact, but is evaluated as a potential source to groundwater in the next section.

Table 2-7
Soil Frequency of Exceedances of Proposed FMCLs in the Unpaved Shoreline Area

Information on COPC			Information about Detected Results[1]					Information About Exceedances[1] Proposed Shoreline FMCL (Residential Direct Contact)				COC Outcome
CAS Number	Constituent of Potential Concern[2]	Units	Number of Results	Number of Detected Results	Percent of Detected Results	Minimum Detected Value	Maximum Detected Value	Residential Direct Contact Component of TMCL[3]	Number of Detected Results that Exceed Residential MCL	Percent of Detected Results that Exceed Residential MCL	Exceedance Factor[4]	Comment (see note 5 for criteria establishing COC status)
Soil Constituents Not Retained as COCs Based on Direct Contact in the Unpaved Shoreline Area at Plant 2 (continued)												
Volatile Organic Constituents (VOCs) (continued)												
120-82-1	1,2,4-Trichlorobenzene	mg/kg	30	1	3.3%	0.022	0.022	22	None	None	None	No residential exceedances.
1330-20-7	Total Xylenes[6]	mg/kg	28	1	3.6%	0.0067	0.0067	580	None	None	None	No residential exceedances.
75-01-4	Vinyl Chloride	mg/kg	28	1	3.6%	0.017	0.017	0.06	None	None	None	No residential exceedances.
Semivolatile Organic Compounds (SVOCs)												
117-81-7	bis(2-ethylhexyl)phthalate	mg/kg	12	None	None	None	None	35	None	None	None	No residential exceedances.
7440-62-2	1-Methylnaphthalene	mg/kg	10	5	50%	0.0035	0.079	16	None	None	None	No residential exceedances.
129-00-0	Pyrene	mg/kg	12	5	42%	0.01	0.16	1,700	None	None	None	No residential exceedances.
Mutagenic Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs)												
--	Benzo(a)pyrene TEQ[6]	mg/kg	12	5	42%	0.008673	0.07932	0.14	None	None	None	No residential exceedances.
Polychlorinated Biphenyls (PCBs)												
1336-36-3	Total PCBs[6]	mg/kg	33	7	21%	0.011	0.145	0.20	None	None	None	No residential exceedances.
Total Petroleum Hydrocarbons (TPH)												
--	Gasoline-Range TPH (GRPH)	mg/kg	15	2	13%	19	46	30	1	6.7%	1.5	Maximum exceedance factor < 2 and less than 10% exceed.
--	Diesel-Range TPH (DRPH)	mg/kg	34	16	47%	5.2	3,200	2,000	1	2.9%	1.6	Maximum exceedance factor < 2 and less than 10% exceed.

Notes:

-- Not available.

1 Number of results and exceedance information for VOCs are based on soil data collected between January 1, 2005, and July 17, 2013; for all other analyte classes these are based on soil data collected prior to July 17, 2013. In some areas of Plant 2, more recent soil data reflecting post-interim action conditions have been collected and analyzed. More recent data is shown on figures and discussed in later sections of Volume X of the Corrective Measures Study as appropriate, but was not used to identify Plant 2 COCs.

2 COPCs included in this table are those identified in Table 2-5, which were derived in the 2011 TMCL Tech Memo (Boeing 2011).

3 Residential Direct Contact Component of TMCL from Table 2-5.

4 The exceedance factor is the maximum concentration divided by the criterion, expressed as a fraction; values greater than 1 occur when there is an exceedance. Exceedance factors are rounded to two significant digits.

5 Criteria used to identify COCs:

a. If the exceedance factor was ≤ 2 and percent exceeding was ≤ 10%, the constituent was eliminated as a COC in accordance with MTCA soil compliance rules for screening constituents in soil found in WAC 173-340-740(7)(e)(i-ii); the use of these rules was approved by USEPA.

b. If exceedance factor was > 10, even a single isolated sample would cause the constituent to be retained as a COC.

c. If maximum exceedance factor was between 2 and 10 AND the number of samples with exceedances was less than 0.1% (1 in 1,000), the constituent was not considered a COC. An exception was made for TCE: one result, located at a depth of 11 feet bgs, exceeds the Residential MCL/Proposed Unpaved Shoreline FMCL. Its depth (at the bottom of the point of compliance) makes direct contact unlikely.

6 An evaluation was performed to ensure the use of summed values for benzo(a)pyrene TEQ, total PCBs, and total xylenes would be protective of exposure to both humans and ecological receptors. Details may be found in Attachment S2A.

Abbreviations:

CAS Chemical Abstract System
COC Constituent of Concern
COPC Constituent of Potential Concern
FMCL Final Media Cleanup Level
MCL Media Cleanup Level
mg/kg Milligrams per kilogram
MTCA Model Toxics Control Act
TEQ Toxic equivalent
TMCL Targer Media Cleanup Level
USEPA U.S. Environmental Protection Agency
WAC Washington Administrative Code

Table 2-8
Soil Leaching Pathway Evaluation for Paved Industrial Area

Information on COPC			Information about Detected Results Deeper than 6 ft bgs [1,2]				Information About Exceedances of the Leaching Screening Level[1]				Outcome of Screening for Potential to Leach to Groundwater	
CAS Number	Constituent of Potential Concern[3]	Units	Number of Results	Number of Detected Results	Percent of Detected Results	Maximum Detected Value	Leaching Screening Level[4]	Number of Detected Exceeding	Percent of Detected Exceeding	Exceedance Factor[5]	Is Constituent a Groundwater COC?	Comment (see Note 6)
Soil COCs Based on the Potential to Leach to Groundwater												
Metals and Inorganics												
7440-43-9	Cadmium	mg/kg	1,021	132	13%	104	3.3	14	1.4%	32	Pending	See Table 2-1 for status as groundwater COC.
7440-50-8	Copper	mg/kg	995	995	100%	310	80	4	0.40%	4	Yes	Evaluated further in Section 4.
Volatile Organic Constituents (VOCs)												
156-59-2	*cis*- 1,2-Dichloroethene	mg/kg	446	75	17%	16	2.6	1	0.22%	6.2	Yes	Evaluated further in Section 4.
79-01-6	Trichloroethene (TCE)	mg/kg	446	96	22%	18	0.051	27	6.1%	360	Yes	Evaluated further in Section 4.
75-01-4	Vinyl Chloride	mg/kg	445	27	6.1%	0.35	0.022	5	1.1%	16	Yes	Evaluated further in Section 4.
Semivolatile Organic Compounds (SVOCs), Polychlorinated Biphenyls (PCBs), and Total Petroleum Hydrocarbons (TPH)												
1336-36-3	Total PCBs[7]	mg/kg	786	81	10%	660	0.0018	81	10%	370,000	Yes	Evaluated further in Section 4.
--	Gasoline-Range TPH (GRPH)[8]	mg/kg	407	30	7.4%	18,000	30	20	4.9%	600	Yes	Evaluated further in Section 4.
--	Diesel-Range TPH (DRPH)[8]	mg/kg	936	255	27.2%	130,000	2,000	28	3.0%	65	Yes	Evaluated further in Section 4.
--	Heavy Oil-Range TPH (ORPH)	mg/kg	650	203	31%	61,000	2,000	12	1.8%	31	Yes	Evaluated further in Section 4.
Soil Constituents that are not of Concern for Leaching to Groundwater												
Metals and Inorganics												
7440-36-0	Antimony	mg/kg	842	13	2%	8	750	None	None	None	No	
7440-38-2	Arsenic	mg/kg	1,005	464	46%	64	20	1	0.10%	3.2	Yes	Soil arsenic concentrations are at natural background; groundwater issue is caused by known geochemical conditions.
7440-39-3	Barium	mg/kg	836	836	100%	198	640	None	None	None	No	
18540-29-9	Chromium(VI)	mg/kg	103	10	10%	1.5	--	None	None	None	No	
7440-48-4	Cobalt	mg/kg	717	717	100%	23.8	--	None	None	None	No	
7439-92-1	Lead	mg/kg	1,021	665	65%	316	1,900	None	None	None	No	
7439-97-6	Mercury as Elemental Mercury	mg/kg	991	227	23%	9	1.5	1	0.10%	6	No	Groundwater demonstrates compliance.
7439-98-7	Molybdenum	mg/kg	343	133	39%	30	20	1	0.29%	1.5	No	Groundwater demonstrates compliance.
7440-02-0	Nickel	mg/kg	937	937	100%	61	210	None	None	None	Pending	See Table 2-1 for status as groundwater COC.
7782-49-2	Selenium	mg/kg	967	35	3.6%	9	1.0	17	1.8%	9.0	No	Groundwater demonstrates compliance.
7440-66-6	Zinc	mg/kg	996	996	100%	3,070	1,400	1	0.10%	2.2	Yes	Single, low level exceedance is insufficient to cause leaching concerns in groundwater. See Table 2-1 for cyanide's status as a groundwater COC.
57-12-5	Cyanide (free)	mg/kg	387	99	26%	33	20	1	0.26%	1.7	Pending	
Volatile Organic Constituents (VOCs)												
71-43-2	Benzene	mg/kg	449	81	18%	0.11	0.093	1	0.22%	1.2	No	The single exceedance is old (from 2008) and is less than 2 times the screening levels.
100-41-4	Ethylbenzene	mg/kg	449	5	1.1%	0.47	0.23	1	0.22%	2.0	No	
75-34-3	1,1-Dichloroethane	mg/kg	445	6	1.3%	0.0061	0.71	None	None	None	No	
75-35-4	1,1-Dichloroethene	mg/kg	445	2	0.45%	0.0016	59	None	None	None	No	

Table 2-8
Soil Leaching Pathway Evaluation for Paved Industrial Area

Information on COPC			Information about Detected Results Deeper than 6 ft bgs [1,2]				Information About Exceedances of the Leaching Screening Level[1]				Outcome of Screening for Potential to Leach to Groundwater	
CAS Number	Constituent of Potential Concern[3]	Units	Number of Results	Number of Detected Results	Percent of Detected Results	Maximum Detected Value	Leaching Screening Level[4]	Number of Detected Exceeding	Percent of Detected Exceeding	Exceedance Factor[5]	Is Constituent a Groundwater COC?	Comment (see Note 6)
Soil Constituents that are not of Concern for Leaching to Groundwater (continued)												
Volatile Organic Constituents (VOCs) (continued)												
75-09-2	Methylene Chloride	mg/kg	445	51	11%	0.015	1.0	None	None	None	No	
91-20-3	Naphthalene[9]	mg/kg	826	76	9.2%	48	16	3	0.36%	3.0	No	The naphthalene exceedances are from the 1990s; the absence of more recent exceedances indicates it is no longer an issue.
79-34-5	1,1,2,2-Tetrachloroethane	mg/kg	445	None	None	None	0.013	None	None	None	No	
127-18-4	Tetrachloroethene (PCE)	mg/kg	445	10	2.2%	0.057	0.41	None	None	None	No	
108-88-3	Toluene	mg/kg	449	30	6.7%	0.023	41	None	None	None	No	
79-00-5	1,1,2-Trichloroethane	mg/kg	445	3	0.67%	0.0046	0.073	None	None	None	No	
120-82-1	1,2,4-Trichlorobenzene	mg/kg	767	1	0.13%	0.06	0.046	1	0.13%	1.3	No	Groundwater demonstrates compliance.
1330-20-7	Total Xylenes[7]	mg/kg	449	12	2.7%	2.7022	200	None	None	None	No	
Semivolatile Organic Compounds (SVOCs), including CPAHs												
117-81-7	bis(2-ethylhexyl)phthalate	mg/kg	441	49	11%	0.53	17	None	None	None	Pending	See Table 2-1 for status as groundwater COC.
7440-62-2	1-Methylnaphthalene	mg/kg	117	27	23%	3.2	--	None	None	None	No	
129-00-0	Pyrene	mg/kg	494	109	22%	58	240	None	None	None	No	
--	Benzo(a)pyrene TEQ[7]	mg/kg	513	101	20%	32.65	0.057	22	4.3%	570	No	Groundwater demonstrates compliance.

Notes:

-- Not available.

1 Number of results and exceedance information for VOCs are based on soil data collected between January 1, 2005, and July 17, 2013; for all other analyte classes these are based on soil data collected prior to July 17, 2013. In some areas of Plant 2, more recent soil data reflecting post-interim action conditions have been collected and analyzed. More recent data is shown on figures and discussed in later sections of Volume X of the Corrective Measures Study as appropriate, but was not used to identify Plant 2 COCs.

2 The leaching pathway is evaluated for soil 6 to 11 ft bgs, on the basis of its potential to leach to groundwater due to proximity to the water table and the tidal fluctuation present at Plant 2.

3 COPCs included in this table are those identified in Table 2-5, which were derived in the 2011 TMCL Tech Memo (Boeing 2011).

4 Leaching component of the TMCL, from Table 2-5.

5 The exceedance factor is the maximum concentration divided by the criterion, expressed as a fraction; values greater than 1 occur when there is an exceedance. Exceedance factors are rounded to two significant digits.

6 Criteria used to identify COCs:

a. If the exceedance factor was ≤ 2 and percent exceeding was ≤ 10%, the constituent was eliminated as a COC in accordance with MTCA soil compliance rules for screening constituents in soil found in WAC 173-340-740(7)(e)(i-ii); the use of these rules was approved by USEPA.

b. If exceedance factor was > 10, even a single isolated sample would cause the constituent to be retained as a COC.

c. If maximum exceedance factor was between 2 and 10 AND the number of samples with exceedances was less than 0.1% (1 in 1,000), the constituent was not considered a COC. Additional constituent-specific considerations were made for common naturally-occuring metals in soil, where groundwater data were available to demonstrate compliance, and for certain VOCs whose only exceedance(s) are more than 5 years old. This rationale is included in the Comment field of the table.

7 An evaluation was performed to ensure the use of summed values for benzo(a)pyrene TEQ, Total PCBs, and Total Xylenes would be protective of exposure to both humans and ecological receptors. Details may be found in Attachment S2A.

8 The October 2014 Draft CMS erroneously included kerosene results in the results for GRPH, rather than in the results for DRPH; this error has been corrected, and information about detections and exceedances have changed from the previous version of the table as a result.

9 Napthalene can be analyzed by both SVOC and VOC methods. The TMCL Tech Memo (Boeing 2011) includes naphthalene in both the VOC and SVOC constituent classes. Therefore, samples pre-dating 2005 were not excluded from the dataset for naphthalene, unlike for other VOCs. To simplify CMS Report tables, naphthalene is included only in the VOC constituent class.

Abbreviations:

CAS Chemical Abstract System
COC Constituent of Concern
COPC Constituent of Potential Concern
ft bgs Feet below ground surface
mg/kg Milligrams per kilogram
MTCA Model Toxics Control Act
TMCL Target Media Cleanup Level
USEPA U.S. Environmental Protection Agency
WAC Washington Administrative Code

Table 2-9
Soil Leaching Pathway Evaluation for Unpaved Shoreline Area

Information on COPC			Information about Detected Results[1,2]					Information About Exceedances of the Leaching Screening Level[1]				Outcome of Screening for Potential to Leach to Groundwater	
CAS Number	Constituent of Potential Concern[3]	Units	Number of Results	Number of Detected Results	Maximum Detected Value	Date Maximum Detect Was Sampled	Depth of Maximum Detect (ft bgs)	Leaching Component of the TMCL[4]	Number of Detected Exceeding	Percent of Detected Exceeding	Exceedance Factor[5]	Is Constituent a Groundwater COC?	Comment (see Note 6)
Soil COCs Based on the Potential to Leach to Groundwater													
Volatile Organic Constituents (VOCs)													
156-59-2	*cis*- 1,2-Dichloroethene	mg/kg	31	3	140	5/25/2011	11	2.6	1	3.2%	54	Yes	Evaluated further in Section 4.
79-01-6	Trichloroethene (TCE)	mg/kg	31	8	2.4	5/25/2011	11	0.051	1	3.2%	47	Yes	Evaluated further in Section 4.
Polychlorinated Biphenyls (PCBs)													
1336-36-3	Total PCBs[7]	mg/kg	50	9	0.15	9/9/2011	0–1	0.0018	9	18%	81	Yes	Evaluated further in Section 4.
Total Petroleum Hydrocarbons (TPH)													
--	Gasoline-Range TPH (GRPH)	mg/kg	29	5	1,900	9/14/1994	12.5	30	1	7%	2	Yes	Evaluated further in Section 4.
--	Diesel-Range TPH (DRPH)	mg/kg	65	25	95,000	11/23/1994	12.5	2,000	1	3%	2	Yes	Evaluated further in Section 4.
--	Heavy Oil-Range TPH (ORPH)	mg/kg	64	23	59,000	5/25/2011	11	2,000	2	4.7%	30	Yes	Evaluated further in Section 4.
Soil Constituents that are not of Concern for Leaching to Groundwater													
Metals and Inorganics													
7440-36-0	Antimony	mg/kg	33	None	None	None	None	750	None	None	None	No	
7440-38-2	Arsenic	mg/kg	37	20	11	9/9/2008	9–10	20	None	None	None	No	
7440-39-3	Barium	mg/kg	35	35	96	9/9/2008	0–1	640	None	None	None	No	
7440-43-9	Cadmium	mg/kg	37	8	3	7/20/2011	0–1	3.3	None	None	None	Pending	See Table 2-1 for status as groundwater COC.
18540-29-9	Chromium(VI)	mg/kg	1	None	None	None	None	--	None	None	None	No	
7440-48-4	Cobalt	mg/kg	30	30	10	5/25/2011	11	--	None	None	None	No	
7440-50-8	Copper	mg/kg	36	36	105	8/26/2002	14–15	80	1	2.8%	1.3	Yes	Single, very low level exceedance is insufficient to cause leaching concerns in groundwater.
7439-92-1	Lead	mg/kg	37	25	184	7/20/2011	0–1	1,900	None	None	None	No	
7439-97-6	Mercury as Elemental Mercury	mg/kg	37	14	0.39	7/20/2011	0–1	1.5	None	None	None	No	
7439-98-7	Molybdenum	mg/kg	22	16	6.2	7/7/2008	9–10	20	None	None	None	No	
7440-02-0	Nickel	mg/kg	35	35	38	7/7/2008 9/9/2008	0–1	210	None	None	None	Pending	See Table 2-1 for status as groundwater COC.
7782-49-2	Selenium	mg/kg	37	None	None	None	None	1.0	None	None	None	No	
7440-66-6	Zinc	mg/kg	36	36	86	9/15/2008	9–10	1,400	None	None	None	Yes	
57-12-5	Cyanide (free)	mg/kg	23	3	0.35	12/3/1993	12.5	20	None	None	None	Pending	See Table 2-1 for status as groundwater COC.
Mutagenic Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs)													
--	Benzo(a)pyrene TEQ[7]	mg/kg	19	5	0.079	9/4/2008	4–5	0.057	1	5.3%	1.4	No	Groundwater demonstrates compliance.
Volatile Organic Constituents (VOCs)													
71-43-2	Benzene	mg/kg	31	6	0.0092	7/7/2008	9–10	0.093	None	None	None	Yes	
75-34-3	1,1-Dichloroethane	mg/kg	31	None	None	None	None	0.71	None	None	None	No	

Table 2-9
Soil Leaching Pathway Evaluation for Unpaved Shoreline Area

Information on COPC			Information about Detected Results[1,2]					Information About Exceedances of the Leaching Screening Level[1]				Outcome of Screening for Potential to Leach to Groundwater	
CAS Number	Constituent of Potential Concern[3]	Units	Number of Results	Number of Detected Results	Maximum Detected Value	Date Maximum Detect Was Sampled	Depth of Maximum Detect (ft bgs)	Leaching Component of the TMCL[4]	Number of Detected Exceeding	Percent of Detected Exceeding	Exceedance Factor[5]	Is Constituent a Groundwater COC?	Comment (see Note 6)
Soil Constituents that are not of Concern for Leaching to Groundwater (continued)													
Volatile Organic Constituents (VOCs) (continued)													
75-35-4	1,1-Dichloroethene	mg/kg	31	None	None	None	None	59	None	None	None	No	
100-41-4	Ethylbenzene	mg/kg	31	None	None	None	None	0.23	None	None	None	Yes	
75-09-2	Methylene Chloride	mg/kg	31	7	0.011	6/6/2011	11.5	1.0	None	None	None	No	
91-20-3	Naphthalene	mg/kg	39	4	0.096	5/25/2011	11	16	None	None	None	Yes	
79-34-5	1,1,2,2-Tetrachloroethane	mg/kg	31	None	None	None	None	0.013	None	None	None	No	
127-18-4	Tetrachloroethene (PCE)	mg/kg	31	None	None	None	None	0.41	None	None	None	No	
108-88-3	Toluene	mg/kg	31	5	0.0049	7/7/2008	9–10	41	None	None	None	No	
79-00-5	1,1,2-Trichloroethane	mg/kg	31	None	None	None	None	0.073	None	None	None	No	
120-82-1	1,2,4-Trichlorobenzene	mg/kg	39	1	0.022	5/25/2011	11	0.046	None	None	None	No	
75-01-4	Vinyl Chloride	mg/kg	31	1	0.017	12/13/2011	11	0.022	None	None	None	Yes	
1330-20-7	Total Xylenes[7]	mg/kg	31	1	0.0067	12/28/2011	11	200	None	None	None	No	
Semivolatile Organic Compounds (SVOCs)													
117-81-7	bis(2-ethylhexyl)phthalate	mg/kg	19	None	None	None	None	17	None	None	None	Pending	See Table 2-1 for status as groundwater COC.
7440-62-2	1-Methylnaphthalene	mg/kg	12	5	0.079	5/25/2011	11	--	None	None	None	No	
129-00-0	Pyrene	mg/kg	19	5	0.16	9/4/2008	4–5	240	None	None	None	No	

Notes:

-- Not available.

1 Number of results and exceedance information for VOCs are based on soil data collected between January 1, 2005, and July 17, 2013; for all other analyte classes these are based on soil data collected prior to July 17, 2013. In some areas of Plant 2, more recent soil data reflecting post-interim action conditions have been collected and analyzed. More recent data is shown on figures and discussed in later sections of Volume X of the Corrective Measures Study as appropriate, but was not used to identify Plant 2 COCs.

2 The leaching pathway is evaluated for soil 6 to 11 ft bgs, on the basis of its potential to leach to groundwater due to proximity to the water table and the tidal fluctuation present at Plant 2.

3 COPCs included in this table are those identified in Table 2-5, which were derived in the 2011 TMCL Tech Memo (Boeing 2011).

4 Leaching component of the TMCL, from Table 2-5.

5 The exceedance factor is the maximum concentration divided by the criterion, expressed as a fraction; values greater than 1 occur when there is an exceedance. Exceedance factors are rounded to two significant digits.

6 Criteria used to identify COCs:

a. If the exceedance factor was ≤ 2 and percent exceeding was ≤ 10%, the constituent was eliminated as a COC in accordance with MTCA soil compliance rules for screening constituents in soil found in WAC 173-340-740(7)(e)(i-ii); the use of these rules was approved by USEPA.

b. If exceedance factor was > 10, even a single isolated sample would cause the constituent to be retained as a COC.

c. If maximum exceedance factor was between 2 and 10 AND the number of samples with exceedances was less than 0.1% (1 in 1,000), the constituent was not considered a COC.

7 An evaluation was performed to ensure the use of summed values for benzo(a)pyrene TEQ, Total PCBs, and Total Xylenes would be protective of exposure to both humans and ecological receptors. Details may be found in Attachment S2A.

Abbreviations:

CAS Chemical Abstract System
COC Constituent of Concern
COPC Constituent of Potential Concern
ft bgs Feet below ground surface
mg/kg Milligrams per kilogram
MTCA Model Toxics Control Act
TEQ Toxic equivalent
TMCL Target Media Cleanup Level
USEPA U.S. Environmental Protection Agency
WAC Washington Administrative Code

Table 2-10
Summary of Soil and Groundwater COCs

CAS Number	Constituent of Potential Concern[1]	Retained as a Soil COC		Retained for Leaching Evaluation		Groundwater COC (see Table 2-4)
		Paved Industrial Area	Unpaved Shoreline Area	Paved Industrial Area	Unpaved Shoreline Area	
Constituents Being Evaluated as COCs in Soil and/or Groundwater						
Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs)						
--	Benzo(a)pyrene TEQ	Yes				
Polychlorinated Biphenyls (PCBs)						
1336-36-3	Total PCBs	Yes		Yes	Yes	Yes
Total Petroleum Hydrocarbons (TPH)						
--	Gasoline-Range TPH (GRPH)	Yes		Yes	Yes	Yes, using BTEXN constituents.
--	Diesel-Range TPH (DRPH)	Yes		Yes	Yes	
--	Heavy Oil-Range TPH (ORPH)	Yes	Yes	Yes	Yes	
Volatile Organic Constituents (VOCs) not including pre-2005 data						
71-43-2	Benzene					Yes
156-59-2	*cis* -1,2-Dichloroethene			Yes	Yes	Yes
100-41-4	Ethylbenzene					Yes
91-20-3	Naphthalene					Yes
79-01-6	Trichloroethene (TCE)			Yes	Yes	Yes
75-01-4	Vinyl Chloride			Yes		Yes
Semivolatile Organic Compounds (SVOCs)						
117-81-7	bis(2-ethylhexyl)phthalate					Pending[2]
Metals[3]						
7440-38-2	Arsenic					Yes
7440-43-9	Cadmium			Yes		Pending[2]
7440-50-8	Copper			Yes		Yes
7440-02-0	Nickel					Pending[2]
7440-66-6	Zinc					Yes
Other Inorganics						
57-12-5	Cyanide (free)	Yes				Pending[2]
Constituents Not Retained as COCs in Either Soil or Groundwater[3]						
Volatile Organic Constituents (VOCs) not including pre-2005 data						
75-34-3	1,1-Dichloroethane					
75-35-4	1,1-Dichloroethene					
75-09-2	Methylene Chloride					
79-34-5	1,1,2,2-Tetrachloroethane					
127-18-4	Tetrachloroethene (PCE)					
108-88-3	Toluene					
79-00-5	1,1,2-Trichloroethane					
120-82-1	1,2,4-Trichlorobenzene					
1330-20-7	Xylenes (total)					
Semivolatile Organic Compounds (SVOCs)						
7440-62-2	1-Methylnaphthalene					
129-00-0	Pyrene					
Metals[4]						
7440-36-0	Antimony					
7440-39-3	Barium					
18540-29-9	Chromium (VI)					
7440-48-4	Cobalt					
7439-92-1	Lead					
7439-97-6	Mercury as Elemental Mercury					
7487-94-7	Mercury as Inorganic Mercury Salts					
7439-98-7	Molybdenum					
7782-49-2	Selenium					

Notes:

-- Not available.

1 This table includes only those constituents identified as COCs in Tables B.1a through B.1e of the TMCL Tech Memo (Boeing 2011).

2 See Table 2-1 for status as a groundwater COC.

3 Site soil and groundwater quality has changed as a result of the performance of interim measures, soil excavations/removal actions required to support construction projects, facility upgrades, demolition and/or construction of infrastructure, and the demolition or construction of the site's buildings. As a result, many constituents that were identified as COPCs in the 2011 TMCL Tech Memo no longer meet the criteria to be considered COCs in either soil or groundwater based on current site data.

4 Iron and manganese data were collected in both soil and groundwater. Iron and manganese concentrations in both media are less than natural background concentrations, with the exception of a small, localized hotspot within OA-1/OA-2 where iron and manganese data exceeded their soil TMCLs. This source area was removed as part of an interim measure (*Interim Measure Completion Report: Duct Bank Line in the 2-31/2-40s/2-66 Areas;* Golder 2011); thus, iron and manganese concentrations remaining on-site are typical of natural background conditions.

Abbreviations:

BTEXN Benzene, toluene, ethylbenzene, xylenes, and naphthalene
CAS Chemical Abstract System
COC Constituent of concern
COPC Constituent of potential concern
TEQ Toxic equivalent
TMCL Target Media Cleanup Level

Table 3-1: Plant 2 Excavated Soil Locations Associated with Construction Projects, Interim Measures, and Corrective Measures (1986 through 2016)

Soil Excavation ID[a]	Date Documented	Location on Map	Associated Documentation (Provided on DVD In Attachment S3A)[b]	Purpose for Excavation[c]	Date Excavation Conducted	Associated RCRA Unit	Material Removed	Quantity Removed (CY)
Uplands Area Construction Projects and Interim Measures								
1	1986	South of Building 2-44 and east of Building 2-51	OA 9 Interim Measure First Semiannual Report (EPI 2009)	IM	1986	OA 9 - Former USTs PL-16, -17, and -18 and SWMU 2-78.6	Soil	20
2	1995	Southwest corner of Building 2-66 and Southwest Yard	Construction Completion Report, Interim Corrective Action, Buildings 2-10 and 2-66 (Weston 1995)	IM	1994	OA 1 and OA 2 - Building 2-66 Southwest and Building 2-66 Soil	Soil	300
3	1997	Beneath roadway south of Building 2-80	RCRA Facility Investigation, Soil Investigation Interim Report, Boeing Plant 2 (Weston 1997)	IM	1992	OA 3 - Former UST PL-23	Soil	5
4	1998	Building 2-41 north wall	Remedial Action Completion Report, SWMU 2-41.33 Anodic Tank Line (Weston 1998)	IM	December 1993 - December 1997	SWMU 2-41.33 - Deactivated Anodic Tank Line	Soil and concrete	200
5	1998	Southeast corner of Building 2-70	SWMU 2-70.55 East Steam Clean and Underground Bulk Storage Tank Remedial Action Completion Report (Weston 1998)	IM	March 1998	SWMU 2-70.55 - East Steam Clean Area and UST	Soil	3
6	1998	West of Building 2-49	Outfall 12 and Underflow Flume Remedial Action Completion Report (Weston 1998)	IM	1997	OA 19 - Stretch Press Pit and Outfall No. 12	Soil	22
7	1998	East of south end of Building 2-15	Building 2-15 Underground Fuel Storage Tank, Remedial Action Completion Report (Weston 1998)	CP	October 1997	None	Soil	1,440
8	1999	Beneath roadway south of Building 2-80	OA 3 Former UST PL-23 Interim Measures Completion Report (Weston 1999)	IM	March 1998	OA 3 - Former UST PL-23	Soil	80
9	1999	Eastern boundary of South Yard Area	SWMU 79 Cistern Interim Measures Completion Report (Weston 1999)	IM	May 1999	SWMU 79.A - Cisterns 1, 2, and 3	Soil	905
10	1999	Eastern boundary of south yard area by Northeast corner of Building 2-87	SWMU 79 Cistern Interim Measures Completion Report (Weston 1999)	IM	July 1999	SWMU 79.B - Cistern 4	Soil and concrete	540
11	2000	Adjacent to south side of former Building 2-68	Building 2-68 Underground Fuel Storage Tank, Soil Removal Completion Report (Weston 2000)	CP	1987	UST - PL-20 (Kerosene)	Soil	10
12	2000	South wall of Building 2-109	SWMU 2-87.65 Machine Pit, SWMU 77 PCB Retention Tank, SWMU 78.B Oil/Water Separator, and OA 16 Former Hazardous Waste Storage Facility Interim Measures Completion Report (Weston 2000)	IM	May 1999	SWMU 2-87.65 - Machine Pit	Soil	220
13	2000	South side of Building 2-87	SWMU 2-87.65 Machine Pit, SWMU 77 PCB Retention Tank, SWMU 78.B Oil/Water Separator, and OA 16 Former Hazardous Waste Storage Facility Interim Measures Completion Report (Weston 2000)	IM	May 1999	SWMU 78.B - Oil/Water Separator at Building 2-87	Soil and concrete	15
14	2000	Northern edge of South Yard Area Reclamation Yard near Building 2-104	SWMU 2-87.65 Machine Pit, SWMU 77 PCB Retention Tank, SWMU 78.B Oil/Water Separator, and OA 16 Former Hazardous Waste Storage Facility Interim Measures Completion Report (Weston 2000)	IM	May 1999	OA 16 - Soil and Groundwater (SWMU 2-104.71)	Soil	42
15	2000	Building 2-87, Adjacent to Southeast corner Building 2-110	SWMU 2-87.65 Machine Pit, SWMU 77 PCB Retention Tank, SWMU 78.B Oil/Water Separator, and OA 16 Former Hazardous Waste Storage Facility Interim Measures Completion Report (Weston 2000)	IM	May 1999	SWMU 77 - PCB Retention Tank (Vault 19)	Soil	72

Table 3-1: Plant 2 Excavated Soil Locations Associated with Construction Projects, Interim Measures, and Corrective Measures (1986 through 2016)

Soil Excavation ID[a]	Date Documented	Location on Map	Associated Documentation (Provided on DVD In Attachment S3A)[b]	Purpose for Excavation[c]	Date Excavation Conducted	Associated RCRA Unit	Material Removed	Quantity Removed (CY)
16	2000	North-central portion of Building 2-44	Technical Memorandum - SWMU/AOC/OA - Specific Data Presentation, RCRA Corrective Measures Study - Boeing Plant 2 (Weston 2000)	IM	June 1999	OA 21 - Building 2-44 Machine Shop Area	Soil	120
17	2001	Central portion of Building 2-83	AOC 2-84.62 - Machine Pits Interim Measures Cleanup Report (Weston 2001)	IM	June 2000	AOC 2-84.62 - Machine Pits	Soil	50
18	2005	New Building 2-124	Technical Memorandum: Boeing Plant 2, 2-124 Area Excavation Evaluation (Golder 2005)	CP	September - October 2005	None	Asphalt and soil	unknown
19A-19N	2005	A - D, G - N in North Central and West Central Building 2-10	Technical Memorandum: Addendum 3 to Boeing Plant 2, 2-10 Area Excavation Evaluation (Golder 2005)	CP	September - October 2005	AOC 2-10.3A - North TCE Degreaser	Soil	unknown
20	2005	19 footings inside Building 2-122	Technical Memorandum: Addendum to September 16, 2005, Boeing Plant 2, Building 2-122 Integrated Test Vehicle Footing Excavation Evaluation (Golder 2005)	CP	October 2005	None	Concrete, base rock, and fill	120
21	2005	South of Building 2-122	Technical Memorandum: Boeing Plant 2, Wastewater Containment Structure Area Pre- and Post-Excavation Sampling Results (Golder 2005)	CP	October - December 2005	None	Asphalt and soil	unknown
22	2005	Excavations E and F in Building 2-10	Technical Memorandum: Field Observations 2-10 Building Construction Excavations E and F (Golder 2005)	CP	November 2005	AOC 2-10.3A - North TCE Degreaser	Soil	18
23	2006	Perimeter of Building 2-65 slab	Construction Completion Report, Installation of Temporary Stormwater System Treatment and Control System (Golder 2006), which was included as Attachment B to the Interim Measure Work Plan, Stormwater X & Y Lines (OA 23.1 and OA 23.2) (Golder 2006)	CP	March 2006	None	Concrete, asphalt, and soil	240
24	2006	West side of Building 2-15	Interim Measure Completion Report Removal of SWMU 2-15.7A, Underground Storage Tank PL-52, at Boeing Plant 2, Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2006)	IM	September 2006	SWMU 2-15.7A - Two Waste Storage Tanks (PL-52 and PL-53)	Soil	24
25	2006	South and east of the 2-88 Building	Technical Memorandum: Boeing Plant 2, SCL Pole and Guy Locations 2-88 Building (Golder 2006)	CP	2006	SWMU 2-89.68 - Reclamation Yard	Soil	2
26	2007	New tank line inside Building 2-122	Technical Memorandum: Boeing Plant 2, Building 2-122 Line Equipment Foundation and Sump Excavation, Post-Excavation Sampling Results (Golder 2007)	CP	December 2005	None	Concrete and soil	479
27	2007	LAR outside the southeast corner of Building 2-122	Technical Memorandum: Boeing Plant 2, LAR Area Excavation Evaluation (Golder 2007)	CP	February 2006	None	Asphalt and soil	25
28	2007	Jet-A, south side of Building 2-120	Technical Memorandum: Jet Fuel Tank PLA-1 Reactivation Observations and Results: Hand Auger Borings and Excavations (Golder 2007)	CP	November - December 2006	OA 6 - Northeast Area	Asphalt and soil	46
29	2007	Water jet, composite saw, 3-axis, 5-axis machine foundations in Building 2-10	Technical Memorandum: Boeing Plant 2, Building 2-10 New Foundations Excavation Summary (Golder 2007)	CP	2006	OA 5 - Fuel Station Area	Soil	200
30	2007	SWMU 2-64.48	Underground Waste Collection Sump Closure Report, Removal of Underground Waste Collection Sump at SWMU 2-64.48 Boeing Plant 2 (Golder 2007)	RCRA Removal	May 2007	SWMU 2-64.48 - Underground Waste Tank	Soil and concrete	5

Table 3-1: Plant 2 Excavated Soil Locations Associated with Construction Projects, Interim Measures, and Corrective Measures (1986 through 2016)

Soil Excavation ID[a]	Date Documented	Location on Map	Associated Documentation (Provided on DVD In Attachment S3A)[b]	Purpose for Excavation[c]	Date Excavation Conducted	Associated RCRA Unit	Material Removed	Quantity Removed (CY)
31	2007	Building 2-64, central 2-60s Area	Technical Memorandum: Building 2-64 Halo, Below Ground Demolition Completion (Golder 2007)	CP	May 2007	SWMU 2-64.49 - Air Compressor Building Sump and Accumulation Area SWMU 2-64.48 - Underground Waste Tank SWMU 78.C - Oil Water Separator SWMU 77.B - PCB Retention Tank	Asphalt, concrete, base rock, and fill	192
32	2007	Fleet parking area between Building 2-10 and 16th Avenue South	Technical Memorandum: Stormline I Modifications Observations and Results: Catch Basin Excavations (Golder 2007)	CP	June 2007	None	Soil	5
33	2007	Two new Mazak foundations in Northeast portion of Building 2-10	Technical Memorandum: Boeing Plant 2, Building 2-10 Mazak Foundations Excavation Summary (Golder 2007)	CP	July 2007	None	Base rock, fill, and soil	21
34	2007	Building 2-88, between column lines B and B.5 and column lines 7 and 9	Technical Memorandum: Building 2-88 Mazak Foundation Completion (Golder 2007)	CP	July 2007	SWMU 2-89.68 - Reclamation Yard	Concrete, base rock, fill, and soil	60
35	2008	Parking lot on the north side of Building 2-10	Technical Memorandum: Completion of Building 2-10, Parking Lot 19 Modifications Observations and Results: Demolition and Soil Excavation (Golder 2008)	CP	December 2007	OA 4 - Scattered PCB Exceedances	Concrete, asphalt, landscape mulch, soil, fill, and/or base rock	90
36	2008	Building 2-45, northeast of 2-60s Area	Technical Memorandum: Completion of Building 2-45 Foundation Removal Observations and Results: Removal & Soil Excavation (Golder 2008)	CP	December 2007 - March 2008	None	Concrete, soil, fill, and base rock	50
37	2008	Building 2-88, between column lines C and D and column lines 4 and 6	Technical Memorandum: Completion of Building 2-88 New Foundation Excavations Observations and Results: Concrete Removal and Excavations (Golder 2008)	CP	March 2008	SWMU 2-89.68 - Reclamation Yard	Concrete, base rock and fill material	25
38	2008	East side of Building 2-10 outside the Building wall for new machine foundation	Technical Memorandum: Completion of Building 2-10, New Exterior Foundation Excavation (Golder 2008)	CP	July 2008	OA 5 - Fuel Station Area	Concrete (no base rock or fill was removed)	15
39	2008	Four new concrete footings tie beams north central Building 2-10	Technical Memorandum: Building 2-10, Tie Beams and Footings (Golder 2008)	CP	August 2008	AOC 2-10.2A - Decommissioned Machine Sumps	Concrete, base rock, and fill material	58
40	2008	Gate B-60, east side of the 2-10 Area	Technical Memorandum: Excavation for new Guard Station at Gate B-60 (Golder 2008)	CP	November 2008	OA 6 - Northeast Area	Concrete, base rock, and fill	35
41	2009	East of Building 2-31	Technical Memorandum: Completion of Excavation for 2-38 Utility Chase (Golder 2009)	CP	February 2009	None	Asphalt pavement and base rock	3

Table 3-1: Plant 2 Excavated Soil Locations Associated with Construction Projects, Interim Measures, and Corrective Measures (1986 through 2016)

Soil Excavation ID[a]	Date Documented	Location on Map	Associated Documentation (Provided on DVD In Attachment S3A)[b]	Purpose for Excavation[c]	Date Excavation Conducted	Associated RCRA Unit	Material Removed	Quantity Removed (CY)
42	2010	Jet-A, catch basin 3-332D	Technical Memorandum: Trench Excavation - Near Jet-A Fuel Tanks (Golder 2010)	Spill Cleanup	October 2010	OA 6 - Northeast Area	Soil and concrete catch basin	5
43	2011	Duct Bank, 2-31, 2-40s, and 2-66 Areas	Interim Measure Completion Report Duct Bank Line in the 2-31/2-40s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2011)	IM	June - December 2010	SWMU 2-41.33 - Deactivated/Anodic Tank/Line SWMU 2-41.36 - Underflow Flume OA 1 - Building 2-66 Southwest OA 2 - Building 2-66 Soil OA 23.1 - Storm Line X OA 23.2 - Storm Line Y	Soil	7,700
44	2011	Storm Line B, northwest corner of the 2-10 Area	Technical Memorandum: Partial Completion of Storm Line B Modifications (Golder 2011)	CP	November - December 2010	None	Soil	30
45	2011	Building 2-10 to Building 2-31	Addendum to Interim Measure Completion Report Duct Bank Line in the 2-31/2-40s/2-66 Areas, Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2010)	CP	March 2011	OA 4 - Scattered PCB Exceedances OA 8 - Building 2-09 Chrome Waste Tank (SWMU 2-09.2)	Soil	420
46	2011	Between 2-40 and 2-31 Buildings	Technical Memorandum: Completion of Temporary Dust Wall Between Buildings 2-40 and 2-31 (Golder 2011)	IM	May 2011	SWMU 2-31.26 - Anodizing Tank/Line	Soil	30
47	2011	Building 2-127 South Yard	Technical Memorandum: Completion of New Boiler House, Building 2-127 (Golder 2011)	CP	December 2010 - March 2011	None	Soil	350
48	2011	South side of Building 2-10	Technical Memorandum: Completion of 2-10 Area Fire Hydrant and PIV Removal and Replacement (Golder 2011)	CP	June - July 2011	None	Asphalt, base rock, pipe bedding material, and fill	15
49	2011	North Area Storm Retrofit	Technical Memorandum: North Area Stormwater System Retrofit (Golder 2011)	CP	June - July 2011	None	Soil	1,600
50	2011	2-10 and North Areas	Technical Memorandum: Completion of Conduit Trench Excavations - Steam Utilidor (Golder 2011)	CP	July 2011	None	Base rock and fill	9
51	2011	Inside Building 2-88	Technical Memorandum: Completion of Isolation Pad, Building 2-88 (Golder 2011)	CP	November 2011	SWMU 2-89.68 - Reclamation Yard	Concrete	3
52	2011	Inside Building 2-88	Technical Memorandum: Completion of Parpas Foundation Excavation Building 2-88 (Golder 2011)	CP	December 2011-January 2012	SWMU 2-89.68 - Reclamation Yard	Fill, bedding, and soil materials	8
53	2013	North Stormwater, 2-40s Area	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	North Stormwater Excavation SWMU 2-41.36 - Underflow Flume & SB-04114 (c) Target Excavation SB-04136 (b) SWMU 2-41.30 - Manhole Vault (a)	Soil	60,000

Table 3-1: Plant 2 Excavated Soil Locations Associated with Construction Projects, Interim Measures, and Corrective Measures (1986 through 2016)

Soil Excavation ID[a]	Date Documented	Location on Map	Associated Documentation (Provided on DVD In Attachment S3A)[b]	Purpose for Excavation[c]	Date Excavation Conducted	Associated RCRA Unit	Material Removed	Quantity Removed (CY)
54	2013	South Stormwater 2-66 Area - 2-40s Area	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	OA 14, Building 2-49 Machine Pits (a) Target Excavation PL2-013B/PL2-607A (b) Target Excavation 2-66-DP-30 (c) 2-66 Sheetpile Containment (d)	Soil	N/A - included as part of 60,000 cy
55	2013	East of Building 2-44 and west of Building 2-48	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	Target Excavation OA 9	Soil	N/A - included as part of 60,000 cy
56	2013	East end former 2-44 Building footprint	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	OA 21 - Building 2-44 Machine Shop Area	Soil	N/A - included as part of 60,000 cy
57	2013	East end former 2-44 Building footprint	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	Target Excavation 2-40-DP-013/SPL-044-029	Soil	N/A - included as part of 60,000 cy
58	2013	North side of east end former 2-44 Building footprint	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	Target Excavation UST PL-38	Soil	N/A - included as part of 60,000 cy
59	2013	North side of east end former 2-44 Building footprint	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	Target Excavation Sump U44-112	Soil	N/A - included as part of 60,000 cy
60	2013	North side of east end former 2-44 Building footprint	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	Target Excavation DP-4408	Soil	N/A - included as part of 60,000 cy
61	2013	North side of east end former 2-44 Building footprint	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	Target Excavation 2-60-DP-17	Soil	N/A - included as part of 60,000 cy
62	2013	Central portion of east half of 2-41 Building footprint	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	Target Excavation DP-4107	Soil	N/A - included as part of 60,000 cy
63	2013	Central portion of east half of 2-41 Building footprint	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	2-41 Light Pole Base Excavation	Soil	N/A - included as part of 60,000 cy

Table 3-1: Plant 2 Excavated Soil Locations Associated with Construction Projects, Interim Measures, and Corrective Measures (1986 through 2016)

Soil Excavation ID[a]	Date Documented	Location on Map	Associated Documentation (Provided on DVD In Attachment S3A)[b]	Purpose for Excavation[c]	Date Excavation Conducted	Associated RCRA Unit	Material Removed	Quantity Removed (CY)
64	2013	North 2-40 Building footprint	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	Target Excavation 2-40-DP-056	Soil	N/A - included as part of 60,000 cy
65	2013	North 2-41 Building footprint	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	Target Excavation SB-04105	Soil	N/A - included as part of 60,000 cy
66	2013	North 2-41 Building footprint	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	Target Excavation P2IM-SM-017	Soil	N/A - included as part of 60,000 cy
67	2013	Northeast 2-41 Building footprint	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	Target Excavation SB-04107	Soil	N/A - included as part of 60,000 cy
68	2013	Northwest 2-40 Building footprint	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	Target Excavation IA1-WC-01	Soil	N/A - included as part of 60,000 cy
69	2013	Northwest 2-40 Building footprint	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	Target Excavation UST-1 (UPL-811)	Soil	N/A - included as part of 60,000 cy
70	2013	West 2-31 Building demolished portion footprint	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	Target Excavation 2-31-DP-07	Soil	N/A - included as part of 60,000 cy
71	2013	West 2-31 Building demolished portion footprint	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	Target Excavation NS-03-31	Soil	N/A - included as part of 60,000 cy
72	2013	West 2-31 Building demolished portion footprint	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	Target Excavation NS-02-31	Soil	N/A - included as part of 60,000 cy
73	2013	West 2-31 Building demolished portion footprint	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	Target Excavation DP-3101	Soil	N/A - included as part of 60,000 cy
74	2013	West 2-31 Building demolished portion footprint	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	Target Excavation 2-31-DP-34	Soil	N/A - included as part of 60,000 cy

Table 3-1: Plant 2 Excavated Soil Locations Associated with Construction Projects, Interim Measures, and Corrective Measures (1986 through 2016)

Soil Excavation ID[a]	Date Documented	Location on Map	Associated Documentation (Provided on DVD In Attachment S3A)[b]	Purpose for Excavation[c]	Date Excavation Conducted	Associated RCRA Unit	Material Removed	Quantity Removed (CY)
75	2013	Between the south end of the former 2-63 and 2-65 Building footprints	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	Target Excavation SB-06304	Soil	N/A - included as part of 60,000 cy
76	2013	Northeast former 2-66 Building footprint	Interim Measure Completion Report, 2010-2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas. Boeing Plant 2 Seattle/Tukwila, Washington (Golder 2013)	IM	2010 - 2012	Target Excavation 2-60-DP-25	Soil	N/A - included as part of 60,000 cy
77	2013	Building 2-80	Technical Memorandum: Completion of Gas Line Relocation (Golder 2013)	CP	April - June 2013	None	Pavement, base materials, and soil	102
78	2013	Inside southeast portion of Building 2-88	Technical Memorandum: Building 2-88 Mazak Foundation Completion (Golder 2013)	CP	August 2013	SWMU 2-89.68 - Reclamation Yard	Concrete, base gravel, fill, and subgrade soil	10
79	2013	West of Building 2-31	Technical Memorandum: Building 2-31 Truck Lane Completion (Golder 2013)	CP	August - September 2013	None	Topsoil, native soil/imported fill, and crushed concrete	120
80	2013	Inside Building 2-10	Technical Memorandum: Building 2-10 Mazak Trench Completion (Golder 2013)	CP	September 2013	AOC 2-10.3A - North TCE Degreaser AOC 2-10.1AA - Hydraulic Stamp Machines and Sumps OA 4 - Scattered PCB Exceedances	Concrete, gravel base bedding, and fill material	4
81	2013	Inside Building 2-10	Technical Memorandum: Building 2-10 Mazak Foundations Completion (Golder 2013)	CP	October 2013	None	Concrete, base gravel, fill, and subgrade soil	28
82	2013	West of Gate B-18	Technical Memorandum: South Entry Gate Light Poles Completion (Golder 2013)	CP	October - November 2013	None	Asphalt, base gravel, fill, and subgrade soil	93
83	2013	South of Building 2-10	Technical Memorandum: Building 2-09 Fire Service Disconnect at 2-10 Area Fire Hydrant Completion (Golder 2013)	CP	November 2013	None	Base rock, pipe bedding, and fill materials	3
84	2014	Southwest corner of the 2-81 Building, northeast corner of the 2-126 Building, and east central portion of the 2-10 Building	Technical Memorandum: 2-81 Building Canopy, 2-116 Building Briat Landing, and 2-10 Building New Crane Footing Foundation and Sewer Tie-in Projects Completions (Golder 2014)	CP	December 2013 - April 2014	AOC 2-10.2A - Decommissioned Machine Sumps AOC 2-80.58 - Deactivated Sump	Base rock, fill materials, and soil	5
85	2014	East side of the 2-10 Building	2-10 Fire Protection Valve Repair Email (Golder 2014)	CP	February 2014	None	Base rock and soil	16
86	2014	Southwest corner of Boeing Plant 2	SCL Dallas Crossing Geotech Boring Email (Golder 2014)	CP	April 2014	AOC 2-66.53 - TCE Degreaser	Soil	150
87	2014	North of the 2-31 Building	Underground Storage Tank (UST) UPL-065 Removal: UST Site Assessment Report (Golder 2014)	CP	October 2014	None	Concrete, asphalt, base gravel, fill, and soil	35

Table 3-1: Plant 2 Excavated Soil Locations Associated with Construction Projects, Interim Measures, and Corrective Measures (1986 through 2016)

Soil Excavation ID[a]	Date Documented	Location on Map	Associated Documentation (Provided on DVD In Attachment S3A)[b]	Purpose for Excavation[c]	Date Excavation Conducted	Associated RCRA Unit	Material Removed	Quantity Removed (CY)
88	2015	East of the 2-127 Building	Technical Memorandum: Pavement Repair Stormline Z Area Completion (Golder 2015)	CP	September - October 2014	None	Concrete, asphalt, and subgrade soil	1,200
89	2015	North and south of the new 16th Avenue South Bridge	Technical Memorandum: Plant 2 Stormlines I and J Improvements Completion (Golder 2015)	CP	October - December 2014	OA 4 – Scattered PCB Exceedances, OA 8 – Building 2-09 Chrome Waste Tank (SWMU 2-09.2), and SWMU 2-10.8 – Anodic and Alodine Tanks/Lines	Soil	270
90	2015	Southeast portion of 2-88 Building	Technical Memorandum: Building 2-88 Hermle Machine Foundation Completion (Golder 2015)	CP	October - November 2014	SWMU 2-89.68 - Reclamation Yard	Concrete, base gravel, fill, and subgrade soil	100
91	2015	South end of 2-10 Building	Technical Memorandum: 2-10 Building Airline/Electrical Conduit Trench Completion (Golder 2015)	CP	March 2015	SWMU 2-10.8 - Anodic and Alodine Tank Lines	Concrete and soil	8
92	2015	2-10 Building	Technical Memorandum: 2-10 Airplane Control Systems Laboratory Relocation Completion (Golder 2015)	CP	March - April 2015	AOC 2-10.2A - Decommissioned Machine Sumps	Concrete and soil	150
93	2015	North and west of 16th Avenue Bridge	Technical Memorandum: Fire Hydrants Repairs Completion (Golder 2015)	CP	September 2014 - May 2015	None	Concrete and soil	25
94	2015	South of the 2-81 Building	Technical Memorandum: Plant 2 Electrical Power Upgrade Phase 3 Vault 28 Equipment Pads Excavation Completion (Golder 2015)	CP	March - May 2015	SWMU 2-89.68 - Reclamation Yard	Soil	4
95	2015	2-10, 2-25, 2-28, and 2-31 Building areas	Technical Memorandum: Plant 2 Electrical Power Upgrade Completion (Golder 2015)	CP	May 2014 - May 2015	SWMU 2-31.20 - Deactivated Cyanide Hold Area	Concrete, asphalt, and soil	4,292
96	2015	West of the 16th Avenue South Bridge and north of the 2-31 Building	Technical Memorandum: Electrical Power Upgrade - Pavement Repair Areas Completion (Golder 2015)	CP	June - July 2015	None	Concrete, asphalt, and soil	330
97	2016	2-122 Building and at the 2-123 Building	777X Upgrades - 2-122 and 2-123 Foundations and Conduit Trench Completion (Golder 2016)	CP	August 2015 - August 2016	None	Concrete, asphalt, and soil	350
98	2016	OA 11	Interim Measure for OA 11 Construction Completion Report (Floyd|Snider, Inc. 2016)	IM	September 2016	OA 11 - Building 2-72 Area	Soil	750
						Total Construction Projects and Interim Measures		**83,972**

Table 3-1: Plant 2 Excavated Soil Locations Associated with Construction Projects, Interim Measures, and Corrective Measures (1986 through 2016)

Soil Excavation ID[a]	Date Documented	Location on Map	Associated Documentation (Provided on DVD In Attachment S3A)[b]	Purpose for Excavation[c]	Date Excavation Conducted	Associated RCRA Unit	Material Removed	Quantity Removed (CY)
DSOA and Southwest Bank Corrective Measure								
99	2015	Southwest Bank	Corrective Measure Implementation Report, Duwamish Sediment Other Area and Southwest Bank Corrective Measure Boeing Plant 2 Seattle/Tukwila, Washington (Amec Foster Wheeler Environment & Infrastructure, Inc., Dalton, Olmsted & Fuglevand, Inc., and Floyd|Snider, Inc. 2015)	CM	2012 - 2015		Soil	46,200
100	2015	DSOA and Slip 4	Corrective Measure Implementation Report, Duwamish Sediment Other Area and Southwest Bank Corrective Measure Boeing Plant 2 Seattle/Tukwila, Washington (Amec Foster Wheeler Environment & Infrastructure, Inc., Dalton, Olmsted & Fuglevand, Inc., and Floyd|Snider, Inc. 2015)	CM	2012 - 2015	None	Sediment	163,000
						DSOA and Southwest Bank Corrective Measure		**209,200**
							TOTAL	**293,172**

Abbreviations

AOC - Area of Concern
CP - Construction Project
CY - Cubic Yard
DP - Direct Press
DSOA - Duwamish Sediment Other Area
IM - Interim Measure
LAR - Liquid Argon
OA - Other Area
PCB - Polychlorinated Biphenyls
RCRA - Resource Conservation and Recovery Act
SB - Soil Boring
SCL - Seattle City Light
SWMU - Solid Waste Management Unit
TCE - Trichloroethene
UST - Underground Storage Tank
WC - Waste Characterization

[a]Soil Excavation IDs presented on Figure 3-1.
[b]*Not all documents listed in Table 3-1 are included in the reference list in Section 8 of the CMS Report.
[c]CP = Construction Project, IM = Interim Measure

Table 3-2: Groundwater IMs Performed from 1993 through 2017

IM	Location on Map [a]	Description	Associated Documentation (Provided on DVD In Attachment S3C) [b]	Date IM Conducted	Associated RCRA Unit
2-66 Sheetpile IM	SW corner of former 2-66 Building	A sheetpile enclosure was installed around the trichloroethene (TCE) degreaser to isolate soil and groundwater containing elevated concentrations of chlorinated solvents and prevent migration and transport of contaminants through the subsurface.	Construction Completion Report Interim Corrective Action Buildings 2-10 and 2-66. Weston February 10, 1995	November 1993 – May 1994	OA-1
2-66 Sheetpile Density-driven Convection (DDC)	SW corner of former 2-66 Building	Performed mass removal and subsequent capture and destruction of chlorinated VOC COCs in vadose-zone soil and groundwater inside the sheetpile containment structure near the 2-66 Building.	16th and 17th Quarters Performance Monitoring Report for Interim Measure Density-Driven Convection System near Former Building 2-66. Prepared for The Boeing Company. Environmental Partners, Inc. October 12, 2009	Late 2003 – August 2007	OA-1
2-66 Enhanced Reductive Dechlorination (ERD) IM	SW corner of former 2-66 Building	Performed further remediation to dechlorinate and destroy the residual chlorinated VOC mass in groundwater remaining after the DDC IM was completed within the 2-66 Sheetpile using in situ ERD.	2-66 Enhanced Reductive Dechlorination Interim Measure – Final Report. Prepared for The Boeing Company. Environmental Partners, Inc. July 20, 2011	August 2008 – May 2010	OA-1
2-66 Sheetpile Containment Structural Excavation IM	SW corner of former 2-66 Building	(Excavation followed by ERD): Excavated soil located inside the sheetpile containment structure and added remediation substrate (3D Microemulsion™) to the soil and top of the water table prior to backfilling; performed this IM to continue the favorable reductive geochemical conditions initiated by the previous ERD IM.	Interim Measure Completion Report, 2010–2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas, Boeing Plant 2, Seattle/Tukwila, Washington, Golder Associates Inc., May 2013	2010 – 2012	OA-1
Diesel Recovery Area IM	SW corner of former 2-66 Building	Installed a product extraction well and product recovery system to remove floating diesel fuel in monitoring wells near the southwest corner of the 2-66 Building.	Building 2-66 Floating Product Recovery System Interim Measures Completion Report, Weston. February 28, 2003	January 1995 – October 2000	OA-1
OA-12 ERD IM	2-60s Area former building slabs	Performed a pilot-scale ERD IM project on the high-concentration portion of the chlorinated VOC plume present beneath the former 2-63 Building to evaluate if ERD could be successfully implemented in the shallow A-Level of the aquifer.	Other Area 12 Enhanced Reductive Dechlorination Interim Measure Final Report. Prepared for The Boeing Company. Environmental Partners, Inc. September 1, 2011	Summer 2008 – Spring 2011	OA-12
OA-9 Enhanced Aerobic Degradation (EAD)	West of former 2-48 Building	Implemented bioventing for soil and EAD for groundwater at OA-9 to introduce oxygen into subsurface soil and groundwater and enhance biological degradation of petroleum hydrocarbons and non-chlorinated VOCs through aerobic metabolism.	Other Area 9 Interim Measure – Third Semiannual Report, Boeing Plant 2, Seattle/Tukwila, Washington, Environmental Partners, Inc., July 29, 2010	September 2008 – June 2010	OA-9
Western Portion of 2-31 Building IM	West portion of 2-31 Building	Excavated soil located in the west portion of the 2-31 Building and added remediation substrate (3D Microemulsion™) to the soil prior to backfilling to continue the favorable reductive geochemical conditions.	Interim Measure Completion Report, 2010–2012 Soil and Stormwater Management Plan, Demolition and Redevelopment Activities, 2-40s, 2-31 and 2-60s/2-66 Areas, Boeing Plant 2, Seattle/Tukwila, Washington, Golder Associates Inc., May 2013	2010 – 2012	AOC 2-31.21 TCE Degreaser
2-10 Area South Sheetpile IM	SW portion of 2-10 Building	A sheetpile enclosure was installed around south TCE degreaser to contain solvents and prevent migration and transport of contaminants through the subsurface.	Construction Completion Report Interim Corrective Action Buildings 2-10 and 2-66. Weston February 10, 1995	November 1993 – May 1994	AOC 2-10.4A South TCE Degreaser

Table 3-2: Groundwater IMs Performed from 1993 through 2017

IM	Location on Map [a]	Description	Associated Documentation (Provided on DVD In Attachment S3C) [b]	Date IM Conducted	Associated RCRA Unit
2-10 Area North Sheetpile IM	NW portion of 2-10 Building	A sheetpile enclosure was installed around the north TCE degreaser to contain solvents and prevent migration and transport of contaminants through the subsurface.	Construction Completion Report Interim Corrective Action Buildings 2-10 and 2-66. Weston February 10, 1995	November 1993 – May 1994	AOC 2-10.3A North TCE Degreaser
2-10 Area South Sheetpile Soil Vapor Extraction (SVE) and ERD IM	SW portion of 2-10 Building	Performed mass removal and subsequent capture and destruction of chlorinated VOC COCs in vadose-zone soil and groundwater inside the north sheetpile containment structure in the 2-10 Building.	Interim Measure Work Plan for the North and South Sheetpiles in the 2-10 Building Area (AOC 2-10.3A and AOC 2-10.4A) Phase 2: Design and Implementation, CALIBRE and Floyd|Snider, Agency Review Draft, October 13, 2010. Interim Measure and Site Condition Summary for Areas of Concern 2-10.3A and 2-10.4A at Building 2-10, Prepared for The Boeing Company, Calibre and Floyd Snider, June 2017.	2010 – 2017	AOC 2-10.4A South TCE Degreaser
2-10 Area North Sheetpile SVE and ERD IM	NW portion of 2-10 Building	Performed mass removal and subsequent capture and destruction of volatile COCs in vadose-zone soil and groundwater inside the north sheetpile containment structure in the 2-10 Building.	Interim Measure Work Plan for the North and South Sheetpiles in the 2-10 Building Area (AOC 2-10.3A and AOC 2-10.4A) Phase 2: Design and Implementation, CALIBRE and Floyd|Snider, Agency Review Draft, October 13, 2010. Interim Measure and Site Condition Summary for Areas of Concern 2-10.3A and 2-10.4A at Building 2-10, Prepared for The Boeing Company, Calibre and Floyd Snider, June 2017.	2010 – 2017	AOC 2-10.3A North TCE Degreaser
Remedial Optimization of the 2-10 Area North and South Sheetpile IMs	NW and SW portions of 2-10 Building	Recommends implementation of specific remedial optimization measures for SVE and ERD systems within the sheetpile containment structures in the 2-10 Building.	Remedial Optimization for the 2-10 Interim Measures Technical Memorandum, CALIBRE and Floyd|Snider, Agency Review Draft, July 29, 2014. Interim Measure and Site Condition Summary for Areas of Concern 2-10.3A and 2-10.4A at Building 2-10, Prepared for The Boeing Company, Calibre and Floyd Snider, June 2017.	2010-2017	AOC 2-10.3A North TCE Degreaser AOC 2-10.4A South TCE Degreaser
Well Decommissioning:	Various locations	Performed well decommissioning during redevelopment activities for wells that were located in planned construction and demolition areas.	Well Decommissioning Interim Measure Completion Report. Prepared for The Boeing Company. Environmental Partners, Inc. December 31, 2013	May 2010 – August 2013	Various

Notes:
[a] Locations of Groundwater IMs are presented on Figure 3-5.
[b] Not all documents listed in Table 3-2 are included in the reference list in Section 8 of the CMS Report.

Table 4-1: Chlorinated VOC FMCL Exceedances in Groundwater

Exceedance Area ID[a]	Aquifer Level	Constituent(s) Listed in Order of Area Impacted	Concentration Range (ug/L)	Are Exceedances Present at the POC?	Wells Proposed for Monitoring	Stability Evaluation[b]	Comments
cVOC-1	A	VC	0.6 to 31	No, but present at boundary with Jorgensen Forge	Property Boundary Wells plus Location A and PL2-614A	Stable area with decreasing concentrations.	Probe results are generally low double digit ug/L, well results are generally single digit ug/L concentrations. The greatest VC concentration was at probe DP-SY-05.
		TCE	1.1 to 110			Shrinking area with decreasing concentrations.	Three separate areas of TCE exceedences with single digit ug/L concentrations in two areas with the greatest TCE concentration at RCRA unit SWMU 2-91.70.
cVOC-2	B	VC	3.1 to 12	No, but present at boundary with Jorgensen Forge	Property Boundary Wells plus Location A and PL2-614B	Shrinking area with decreasing concentrations.	Based on three detections in the three new B-Level wells that were installed during the DGI.
cVOC-3	A	TCE	2.5 to 29	No	PL2-615A, PL2-616A, PL2-617A, and PL2-618A	Shrinking area with decreasing concentrations.	All wells and most probes at single digit ug/L concentrations.
	A	VC	0.5				
cVOC-4	B	VC	0.2 to 15.9	No	PL2-615B	Stable area with decreasing concentrations.	Greatest concentration at probe location at 15.9 ug/L. All other locations at single digit ug/L concentrations, most are lower than single digit ug/L.
cVOC-5	A	TCE	1.0 to 1,100	Yes	Location A, PL2-614A, PL2-615A, PL2-616A, PL2-617A, and PL2-618A	Stable area with decreasing concentrations.	Primarily single and double digit ug/L concentrations except inside sheetpile and at AOC 2-66.53 TCE degreaser. Greatest concentration at probe 2-66-DP-011.
		VC	0.2 to 900				High concentrations inside sheetpile at well PL2-035A, outside sheetpile concentrations are low double and single digit ug/L.
		cDCE	312 to 870			Shrinking area with decreasing concentrations.	Greatest concentration is in the sample from SW Bank probe 2-66-DP-11. The remaining locations of cDCE exceedances are inside of the 2-66 sheetpile.
cVOC-6	B	VC	0.3 to 4.7	No, but present at boundary with Jorgensen Forge	PL2-614B and PL2-615B	Shrinking area with decreasing concentrations.	All single digit or lower ug/L concentrations.
		TCE	0.9 and 5.0				Two well locations PP-5B-O at 0.9 ug/L and well PL2-008B at 5.0 ug/L
cVOC-7	B	VC	0.2 to 2,300	No	EMF Wells plus PL2-619B and PL2-620B	Shrinking area with decreasing concentrations.	EMF Plume. Greatest concentration in center of plume at well EMF-WF-34, significantly lower concentrations at edges. More recent data from EMF program indicate lower concentrations.
		cDCE	400				EMF Plume. Single probe location, 2-40-DP-14, with non-detections in two shallower and one deeper sample intervals. More recent data from EMF program indicate lower concentrations.
		TCE	1.3				
cVOC-8	A	VC	0.2 to 1.4	No	PL2-617A, PL2-618A, and PL2-619A	Shrinking area with decreasing concentrations.	Based almost solely on probe results. All but one detection < 1 ug/L.
		TCE	0.8				Single probe location 2-60-DP-17.
cVOC-9	C	cDCE	240 and 650	Yes, likely anomalous	None	Difficult to evaluate due to sparse historical C-Level data.	Two probe locations, 2-40-DP-37 and 2-40-DP-38, both with non-detections or cDCE concentrations significantly less than its proposed FMCL in all five shallower sample intervals.
		VC	0.3 to 1.8				Based on four probe locations and one well location. Well PL2-435C had a VC concentration of 1.1 ug/L.

Table 4-1: Chlorinated VOC FMCL Exceedances in Groundwater

Exceedance Area ID[a]	Aquifer Level	Constituent(s) Listed in Order of Area Impacted	Concentration Range (ug/L)	Are Exceedances Present at the POC?	Wells Proposed for Monitoring	Stability Evaluation[b]	Comments
cVOC-10	A	VC	0.2 to 3,600	Yes	PL2-619A, PL2-620A, PL2-621A, and PL2-227A	Stable area with similar concentrations with the exception of 2-31-DP-38.	All single and double digit concentrations except at 2-31-DP-38, which had VC concentration of 3,600 ug/L. Area has since been excavated and remediation substrate (3DMe) placed prior to backfilling.
		TCE	0.8 to 32			Stable area with similar concentrations.	Based on two probe locations, 2-40-DP-40 and 2-40-DP-41. Greatest concentration drops to 4.9 ug/L at 10 ft. bgs and non-detect in deeper samples. Nearby well PL2-420A was non-detect for TCE.
		cDCE	350			Shrinking area with decreasing concentrations.	Based on one probe location, 2-31-DP-38. Well delineated by non-detections and cDCE at concentrations below its FMCL.
cVOC-11	B	VC	0.2 to 0.5	No	PL2-621B	Shrinking area with decreasing concentrations.	All single digit concentrations at five probe locations and one well location, PL2-507B adjacent to East Marginal Way South.
cVOC-12	A	VC	0.2 to 1.0	Yes	PL2-227A	Difficult to evaluate due to sparse historical data.	Three separate small areas of 1 ug/L or lower detections of VC.
		TCE	3.1	No			Based on one probe location 2-10-DP-104 well delineated by non-detections.
cVOC-13	A	TCE	2.2 to 9.0	No	PL2-213A and PL2-214A	Shrinking area with decreasing concentrations.	Two small exceedance areas defined by three probe locations that are well delineated by multiple non-detections.
		VC	0.4 to 9.2				Two small exceedance areas defined by two probe and two well locations that are well delineated by multiple non-detections.
cVOC-14	B	TCE	0.8 and 8.9	No	PL2-214B	Difficult to evaluate due to sparse historical data.	Based on one probe location 2-10-DP-090 and one well location PL2-262B. Well delineated by non-detections.
cVOC-15	A	VC	0.3 to 1,100	Yes	PL2-258A	Shrinking area with decreasing concentrations.	Highest concentration at PL2-212A, next to concrete filled sump inside of sheetpile. Generally single to low double digit ug/L concentrations outside sheetpile.
		cDCE	1,100	No			
		TCE	1.1 to 20	No			
cVOC-16	B	VC	0.3	No	PL2-258B	Shrinking area with decreasing concentrations.	Based on one well location PL2-259B, immediately upgradient of 2-10 north sheetpile.

Notes:
[a]Exceedance Area IDs presented on Figures 4-2D and 4-2E.
[b]Stability evaluated by comparing DGI and more recent data to historical data presented in the DGI work plans.
TCE FMCL = 0.7 ug/L
cDCE FMCL = 130 ug/L
VC FMCL = 0.18 ug/L

Abbreviations:
3DMe - 3D Microemulsion™ by Regenesis™
AOC - Area of Concern
cDCE - cis-1,2-Dichloroethene
CMS - Corrective Measures Study
cVOC - Chlorinated Volatile Organic Compound
DGI - Data Gaps Investigation
DP - Direct Push
EMF - Electrical Manufacturing Facility
FMCL - Final Media Cleanup Level
ID - Identification
IM - Interim Measure
PL2 - Boeing Plant 2
POC - Point of Compliance
RCRA - Resource Conservation and Recovery Act
SW - Southwest
SWMU - Solid Waste Management Unit
TCE - Trichloroethene
ug/L - microgram per liter
VC - Vinyl Chloride

Table 4-2: BTEX or GRPH FMCL Exceedances in Groundwater

Exceedance Area ID[a]	Aquifer Level	Constituent(s) Listed in Order of Area Impacted	Concentration Range (ug/L)	Are Exceedances Present at the POC?	Wells Proposed for Monitoring	Stability Evaluation[b]	Comments
BTEX-1	A	Benzene	5.7	No (but present at boundary with JF)	PL2-602A and PL2-603A	Shrinking area with approximately equal concentrations.	Based on one well location at PL2-603A. Well delineated by data from wells located to the east and west.
BTEX-2	A	Benzene	5.3	No (but present at boundary with JF)	PL2-112A	Shrinking area with decreasing concentrations.	Based on one well location at PL2-113A. Well delineated by data from nearby wells on three sides.
BTEX-3	A	Ethylbenzene	310 and 730	No (but present at boundary with JF)	PL2-007AR and Location A	Difficult to evaluate due to sparse historical ethylbenzene data.	Based on data from well PL2-006AR (730 ug/L) and one probe, 2-66-DP-21 (310 ug/L). Well delineated by data from nearby wells on three sides.
		Benzene	72			Difficult to evaluate due to sparse historical benzene data.	Based on one probe, 2-66-DP-21 in OA-11, Building 2-72 Area. Well delineated by data from nearby wells on three sides.
		GRPH	1,800 and 16,000			Difficult to evaluate due to sparse historical GRPH data.	Based on data from wells PL2-006AR (16,000 ug/L) and PL2-JF04A (1,800 ug/L). Well delineated by data from nearby wells on three sides. Area has since been excavated and backfilled with clean soil.
BTEX-4	A	Ethylbenzene	2.6 to 13	No	PL2-615A	Shrinking area with significantly decreasing concentrations.	Based on two well locations, PL2-018A and PL2-019A and one probe, 2-66-DP-29 in the Diesel Recovery Area. Well delineated by multiple wells and probes. Soil excavation was performed in this area after data gap investigation samples were collected.
		Benzene	8.7 and 10				Based on two probe locations, 2-66-DP-25 and 2-66-DP-29 in the Diesel Recovery Area. Well delineated by multiple wells and probes. Soil excavation was performed in this area after data gap investigation samples were collected.
		GRPH	1,100				Based on a single probe location, 2-66-DP-8. Well delineated in all directions, especially downgradient.
BTEX-5	A	Ethylbenzene	160 and 200	No	None	Shrinking area with significantly decreasing concentrations.	Based on two well locations, PL2-310A and PL2-311A located in OA-9, Former USTs PL-16, 17, 18. Well delineated by multiple wells and probes. The area underwent interim measures and the exceedance area represents post-IM data. Soil excavation was performed in this area after the OA-9 IM was completed and the last round of groundwater samples were collected.
		Benzene	39 and 180				
		GRPH	4,800 and 6,200				
BTEX-6	A	Benzene	9.2 and 9.3	No	None	Difficult to evaluate due to sparse historical benzene data.	Based on two probe locations, 2-40-DP-60 and 2-10-DP-105 in OA-17, Transformer Vaults. Well delineated by wells and probes in all directions.
BTEX-7	A	Ethylbenzene	36	No	None	Shrinking area with decreasing concentrations.	Based on one probe location, 2-10-DP-03, near OA-18, Building 2-40 East Parking Lot Area. Well delineated by multiple wells and probes in all directions.
		Benzene	5.9				
BTEX-8	B	Benzene	31	No, likely anomalous	None	Likely anomalous, A-Level sample from the same probe is non-detect and all surrounding sample locations are non-detect.	Based on one probe location, 2-10-DP-042. Well delineated by non-detects in samples from multiple wells and probes in all directions.

Notes:

[a]Exceedance Area IDs presented on Figures 4-3D and 4-3E.

[b]Stability evaluated by comparing DGI and more recent data to historical data as presented in the DGI work plans.

Benzene FMCL = 1.6 ug/L

Ethylbenzene FMCL = 1.7 ug/L

Abbreviations:

BTEX - Benzene, Toluene, Ethylbenzene & Xylenes
CMS - Corrective Measures Study
DGI - Data Gaps Investigation
DP - Direct Push
FMCL - Final Media Cleanup Level
GRPH - Gasoline Range Petroleum Hydrocarbons
IM - Interim Measure
JF - Jorgensen Forge
OA - Other Area
POC - Point of Compliance
PL2 - Boeing Plant 2
UST - Underground Storage Tank

Table 4-3: Arsenic FMCL Exceedances in Groundwater

Exceedance Area ID[a]	Aquifer Level	Concentration Range (ug/L)	Are Exceedances Present at the POC?	Wells Proposed for Monitoring	Stability Evaluation[b]	Comments
Arsenic-1	A	8.2 to 99.8	No, but present at boundary with Jorgensen Forge	Location A and PL2-614A	Stable area with similar concentrations.	Based on multiple well and probe results. Elevated arsenic concentrations are co-located with VOC-1 area, which has reducing geochemical conditions.
Arsenic-2	A	9.6 to 18.4	No	PL2-615A	Difficult to evaluate due to sparse historical arsenic data.	Based on four scattered probe locations that are well delineated.
Arsenic-3	A	15.3 to 26	Yes	PL2-618A	Shrinking area with decreasing concentrations.	Based on results from two probes and one well, PL2-425A. PL2-425A was a shoreline well that commonly had arsenic concentrations between 10 and 20 ug/L.
Arsenic-4	A	8.3 to 41.5	No	PL2-617A, PL2-618A, PL2-619A, PL2-620A, and PL2-621A	Stable area with similar concentrations.	Based on multiple sampling locations, mostly probes, with single digit to low double digit ug/L concentrations. The two smaller exceedance areas are each based solely on single probe results.
Arsenic-5	A	8.6 and 13	No	PL2-620A and PL2-621A	Stable area with similar concentrations.	Based on two probe locations, 2-40-DP-32 and 2-31-DP-10.
Arsenic-6	A	12.8 to 48.8	No	PL2-214A	Arsenic was not historically analyzed in samples from this area.	Based on three probes and one well inside of the 2-10 south sheetpile.
Arsenic-7	A	10.3	Yes	None	Arsenic was not historically analyzed in samples from this area.	Based on one probe location, 2-10-DP-089.
Arsenic-8	A	14.5 and 17.6	Yes	PL2-271A	Shrinking area with decreasing concentrations.	Based on samples from two wells, PL2-240A and PL2-271A. PL2-271A is a shoreline well that commonly has arsenic concentrations between 15 and 20 ug/L.
Arsenic-9	A	8.3 to 39.3	No	PL2-258A	Stable area with similar concentrations.	Based on multiple locations, mostly probes, with single digit to low double digit ug/L concentrations.
Arsenic-10	A	15.4	No	None	Difficult to evaluate due to sparse historical arsenic data.	Based on one probe location, NA-DP-30.
Arsenic-11	A	1,100	No	PL2-612AR[c]	Difficult to evaluate due to sparse historical arsenic data.	Based on one probe location, NA-DP-34.
Arsenic-12	A	9.0 to 49.8	No	None	Difficult to evaluate due to sparse historical arsenic data.	Four separate areas based on multiple probes and one well, PL2-202A. Well delineated by well and probe data in all directions.
Arsenic-13	C	135	No	None	Can not evaluate due lack of historical C-Level arsenic data.	Based on one well location, PL2-501C. Arsenic was 2.6 ug/L in PL2-501A and non-detect at 0.5 ug/L in PL2-501B.
Arsenic-14	C	9.0 and 16.0	No	None	Stable area with similar concentrations.	Two separate areas, each based on one well location, PL2-153C and PL2-155C.

Notes:

[a]Exceedance Area IDs presented on Figures 4-4D and 4-4E.

[b]Stability evaluated by comparing DGI and more recent data to historical data as presented in the DGI work plans.

[c]Statistical analyses performed with historical and new data after two sampling events to determine if continued monitoring is warranted.

Total Arsenic FMCL = 8.0 ug/L

Abbreviations:

CMS - Corrective Measures Study
DGI - Data Gaps Investigation
DP - Direct Push
FMCL - Final Media Cleanup Level
ID - Identification
NA - North Area
PL2 - Boeing Plant 2
POC - Point of Compliance
VOC - Volatile Organic Compound

Table 4-4: Copper and Zinc FMCL Exceedances in Groundwater

Exceedance Area ID[a]	Aquifer Level	Constituent(s) Listed in Order of Area Impacted	Concentration Range (ug/L)	Are Exceedances Present at the POC?	Wells Proposed for Monitoring	Stability Evaluation[b]	Comments
CuZn-1	B	Zinc	382 and 717	No, but present at boundary with Jorgensen Forge	PL2-602B and PL2-603B[c] plus Location A and PL2-614B	Former A-Level exceedances are gone. B-Level exceedances are likely anomalous.	Zinc results are likely anomalous. Only two detections at concentrations greater than the proposed FMCL were in two of the three new B-Level wells installed during the DGI. Well delineated by nearby B-Level wells with non-detects or detections greater than the proposed FMCL.
CuZn-2	A	Zinc	219 to 305	No, but present at boundary with Jorgensen Forge	PL2-007AR plus Location A and PL2-614A[c]	Stable Area with decreasing concentrations.	Three separate areas, two inside of the 2-66 sheetpile based on wells PL2-021A and PL2-010A. Exceedance area outside of 2-66 sheetpile is based on one probe location, 2-66-DP-33. Zinc concentration in sample from nearby downgradient well PL2-027A was 8.0 ug/L.
CuZn-3	A	Copper	8.5 to 21	No	PL2-615A, PL2-616A, PL2-617A, and PL2-618A	Difficult to evaluate due to sparse historical copper data in this area.	Two separate areas, based on three wells and three probe locations. Copper concentrations in samples from wells PL2-325A, PL2-326A, and PL2-327A were 8.7, 13.8, and 13.2 ug/L, respectively. Greatest value (21.0 ug/L) from probe 2-60-DP-07.
CuZn-4	B	Zinc	166 and 548	No, but present at boundary with Jorgensen Forge	Location A and PL2-614B	Zinc was not historically analyzed in samples from this area.	Based on two piezometer locations, PP-2B-O and PP-5B-O, screened immediately outside of the 2-66 sheetpile.
CuZn-5	A	Copper	8.3 to 74.6	No	PL2-616A and PL2-617A	Difficult to evaluate due to sparse historical copper and zinc data in this area.	Based on data from two wells and six probe locations. Greatest concentration in probe 2-60-DP-25. Well delineated by surrounding probe and well data.
		Zinc	583				Based on one probe location, 2-66-DP-35. Well delineated by data from wells and probes.
CuZn-6	C	Copper	14	No	None	Difficult to evaluate due to sparse historical C-Level data.	Based on one well location, PL2-026C. Copper was non-detect in the sample from B-Level well PL2-026B.
CuZn-7	B	Zinc	66	No	None	Result is likely anomalous.	Based on one probe location, 2-60-DP-026. All surrounding sampling locations have zinc concentrations in low double digit ug/L.
CuZn-8	B	Zinc	170 and 190	Yes, likely anomalous	PL2-619B	Shrinking area with decreasing concentrations.	Based solely on probe results. All A-Level results for wells and probes are non-detect or low. No proposed FMCL exceedances in samples from nearby wells.
CuZn-9	C	Zinc	100 to 160	Yes, likely anomalous	None	Shrinking area with decreasing concentrations.	Based solely on probe results. All A-Level results for wells and probes are non-detect or low. No proposed FMCL exceedances in samples from nearby wells.
CuZn-10	B	Zinc	60 to 190	No	PL2-621B	Zinc was not historically analyzed in samples from this area.	Based solely on seven probe results. Six A-Level results for probes are non-detect one at 10 ug/L. No proposed FMCL exceedances in samples from nearby wells.
CuZn-11	A	Copper	13 to 20.6	No	None	Shrinking area with decreasing concentrations.	Based on three probe results. Copper concentrations in samples from nearby A-Level wells are 0.6 and 1.8 ug/L.
CuZn-12	C	Copper	11	No	None	Difficult to evaluate due to sparse historical C-Level data.	Based on one well location, PL2-501C. PL2-501A sample result was 0.6 ug/L and PL2-501B sample result was non-detect for copper.
CuZn-13	C	Zinc	70	Yes, likely anomalous	None	Difficult to evaluate due to sparse historical C-Level data.	Based on one well location, PL2-227C. A- and B-Level well sample results were both non-detect for zinc.
CuZn-14	B	Zinc	60	No	None	Zinc was not historically analyzed in samples from this area.	Based on one probe location, 2-10-DP-094. Surrounding sampling locations have zinc concentrations at non-detect to low double digit ug/L.
CuZn-15	A	Copper	15.7	No	None	Zinc was not historically analyzed in samples from this area.	Based on one probe location, 2-10-DP-099, inside of the 2-10 south sheetpile. Well delineated by non-detects and low single digit ug/L results from nearby probes and wells.
CuZn-16	A	Copper	9.1 to 17.7	No	None	Copper was not historically analyzed in samples from this area.	Two areas based solely on five probe results. Well delineated by non-detects and low single digit ug/L results from nearby probes.

Table 4-4: Copper and Zinc FMCL Exceedances in Groundwater

Exceedance Area ID[a]	Aquifer Level	Constituent(s) Listed in Order of Area Impacted	Concentration Range (ug/L)	Are Exceedances Present at the POC?	Wells Proposed for Monitoring	Stability Evaluation[b]	Comments
CuZn-17	A	Copper	9.1 and 15.1	No	None	Copper was not historically analyzed in samples from this area.	Two small isolated exceedance areas, each based on a single probe sample.
CuZn-18	C	Zinc	150	No	None	Difficult to evaluate due to sparse historical C-Level data.	Based on one probe location, NA-DP-46. Likely due to saline C-Level groundwater.
CuZn-19	B	Zinc	100 to 120	Yes, likely anomalous	None	Zinc was not historically analyzed in samples from this area.	Four areas each based on isolated single probe locations. Shallower samples from each probe are non-detect for zinc indicating likely anomalous B-Level results.
CuZn-20	B	Copper	31.2	No	None	Difficult to evaluate due to sparse historical copper data in this area.	Based on one well location, PL2-270B. Copper was 2.6 ug/L in the A-Level well and non-detect in the co-located C-Level probe.
		Zinc	90			Difficult to evaluate due to sparse historical zinc data in this area.	Based on one well location, PL2-270B. Zinc was non-detect the A-Level well and 20 ug/L in the co-located C-Level probe.
CuZn-21	A	Copper	10.1 to 60	No	None	Difficult to evaluate due to sparse historical copper data in this area.	Three separate areas, based on two wells, PL2-BF02A and PL2-201A, and two probes, 2-10-DP-08 and 2-10-DP-016. Well delineated with surrounding well and probe data, except for PL2-BF02A, which is located offsite and upgradient.
CuZn-22	A	Copper	8.3 to 43	No	None	Difficult to evaluate due to sparse historical copper and zinc data in this area.	Seven separate areas, each based on a single sampling location, six probes and one well, PL2-440A. Well delineated by surrounding well and probe data.
		Zinc	2,490				Single location at PL2-440A. Zinc was not detected in co-located B- and C-Level wells. Well delineated by surrounding well and probe data.
CuZn-23	C	Zinc	130 and 650	No	None	Difficult to evaluate due to sparse historical C-Level data.	Two separate areas each based on a single well location, PL2-441C and PL2-435C. Well delineated by surrounding well and probe data. Total copper result at PL2-441C was non-detect.

Notes:

[a]Exceedance Area IDs presented on Figures 4-5D and 4-5E.

[b]Stability evaluated by comparing DGI and more recent data to historical data as presented in the DGI work plans.

[c]Data evaluation performed after four sampling events to determine if continued zinc monitoring is warranted.

Total Copper FMCL = 8.0 ug/L

Dissolved Zinc FMCL = 56 ug/L

Abbreviations:

CMS - Corrective Measures Study
Cu - Copper
DGI - Data Gaps Investigation
DP - Direct Push
FMCL - Final Media Cleanup Level
ID - Identification
NA - North Area
PL2 - Boeing Plant 2
POC - Point of Compliance
Zn - Zinc

Table 4-5: Cyanide FMCL Exceedances in Groundwater

Exceedance Area ID[a]	Aquifer Level	Concentration Range (ug/L)	Are Exceedances Present at the POC?	Wells Proposed for Monitoring	Stability Evaluation[b]	Comments
Cyanide-1	A	6 to 64	No	None	Difficult to evaluate due to sparse historical cyanide data in this area.	Based on three wells, PL2-314A, PL2-326A, and PL2-327A and one probe, 2-60-DP-18. Well delineated by data from wells and probes, especially downgradient of the exceedance area. Data are for WAD cyanide, not free cyanide.
Cyanide-2	A	16 and 17	No	None	Shrinking area with decreasing concentrations.	Based on one well PL2-435A and one probe, 2-40-DP-62. Well delineated by data from nearby wells and probes in all directions. Downgradient of OA-18, Building 2-40 East Parking Lot Area. Data are for WAD cyanide, not free cyanide.
Cyanide-3	A	7 to 248	No	None	Shrinking area with decreasing concentrations.	Based on one well, PL2-440A and three probes, 2-40-DP-71, 2-40-DP-73, and 2-40-DP-74 in OA-18, Building 2-40 East Parking Lot Area. Data are for WAD cyanide, not free cyanide.
Cyanide-4	B	6	Yes, see comment	None	Could not evaluate due to lack of historical B-Level cyanide data in this area.	Based on one well location, PL2-013B in OA-1, Building 2-66 Southwest. Data are for total cyanide, not free cyanide.
Cyanide-5	A	5	Yes, see comment	PL2-615A[c]	Could not evaluate due to lack of historical A-Level cyanide data in this area.	Based on one probe location, 2-66-DP-9, well delineated by non-detects in surrounding probes and wells. Data are for total cyanide, not free cyanide.
Cyanide-6	B	8	Yes, see comment	PL2-619B[c]	Could not evaluate due to lack of historical B-Level cyanide data in this area.	Based on one well location, PL2-442B. Cyanide was not detected in the A-Level sample from PL2-442A or in samples from any nearby probes. Data are for WAD cyanide, not free cyanide.

Notes:

[a]Exceedance Area IDs presented on Figures 4-6D and 4-6E.

[b]Stability evaluated by comparing DGI and more recent data to historical data as presented in the DGI work plans.

[c]Free cyanide analyzed semiannually in the well at the specified location. Continued free cyanide analysis will be evaluated after four semiannual shoreline monitoring events are completed.

Free Cyanide FMCL = 1.0 ug/L

Abbreviations:

CMS - Corrective Measures Study
DGI - Data Gaps Investigation
DP - Direct Push
FMCL - Final Media Cleanup Level
ID - Identification
OA - Other Area
PL2 - Boeing Plant 2
POC - Point of Compliance
WAD - Weak Acid Dissociable

Table 4-6: DRPH, MoRPH, or Naphthalene FMCL Exceedances in Groundwater

Exceedance Area ID[a]	Aquifer Level	Constituent(s) Listed in Order of Area Impacted	Concentration Range (ug/L)	Are Exceedances Present at the POC?	Wells Proposed for Monitoring	Stability Evaluation[b]	Comments
DRPH-1	A	Diesel	650	No, but present at boundary with Jorgensen Forge	PL2-603A[c]	Difficult to evaluate due to sparse historical TPH data.	Based on one well location at PL2-603A. Well delineated by data from wells located to the east and west.
DRPH-2	A	Diesel	8,900	No, but present at boundary with Jorgensen Forge	PL2-112A[c]	Difficult to evaluate due to sparse historical TPH data.	Based on one well location at PL2-112A. Well delineated by data from nearby wells on three sides.
		Motor Oil	1,300				
DRPH-3	A	Diesel	1,300 and 11,000	No	None	Shrinking area with decreasing concentrations.	Based on one well, PL2-018A and one probe, 2-66-DP-25 in the Diesel Recovery Area.
		Motor Oil	5,000				Based on one well location at PL2-018A in the Diesel Recovery Area.
DRPH-4	A	Motor Oil	1,500	No, but present at boundary with Jorgensen Forge	PL2-007AR[c]	Shrinking area with decreasing concentrations.	Based on one well location, PL2-006AR at OA-11.
		Diesel	1,100				
DRPH-5	A	Naphthalene	300 to 630	No	PL2-617A	Shrinking area with decreasing concentrations.	Based on data from three wells. Well delineated by data from surrounding wells and probes. Area was remediated during OA-9 Interim Measure and vadose zone soil has since been excavated following building demolition.
DRPH-6	A	Motor Oil	3,400	No	None	Historical data have a 25,000 ug/L reporting limit and therefore non-detects are not comparable.	Based on one well location at PL2-442A. Well delineated by non-detects in samples from two downgradient probes.
DRPH-7	A	Naphthalene	70	No	None	Difficult to evaluate due to sparse historical naphthalene data.	Based on one isolated probe location, 2-10-DP-051 in the 2-10 Area.

Notes:

[a]Exceedance Area IDs presented on Figures 4-7D and 4-7E.

[b]Stability evaluated by comparing DGI and more recent data to historical data as presented in the DGI work plans.

[c]Naphthalene will be analyzed in shoreline well samples as indicator of DRPH and MoRPH.

DRPH FMCL = 500 ug/L

MoRPH FMCL = 500 ug/L

Naphthalene FMCL = 26 ug/L

Abbreviations:

CMS - Corrective Measures Study
DGI - Data Gaps Investigation
DP - Direct Push
DRPH - Diesel Range Petroleum Hydrocarbons
FMCL - Final Media Cleanup Level
ID - Identification
J - The constituent was detected; the associated quantitation limit is an estimated value because quality control criteria were not met.
MoRPH - Motor Oil Range Petroleum Hydrocarbons
NA - North Area
OA - Other Area
PL2 - Boeing Plant 2
POC - Point of Compliance
SW - Southwest
TPH - Total Petroleum Hydrocarbon

Table 4-7: PCB FMCL Exceedances in Groundwater

Exceedance Area ID[a]	Aquifer Level	Concentration Range (ug/L)	Are Exceedances Present at the POC?	Wells Proposed for Monitoring	Stability Evaluation[b]	Comments
PCB-1	A	0.12 and 0.8	No, but present at boundary with Jorgensen Forge	PL2-007AR and Location A[c]	Shrinking area with decreasing concentrations.	Based on two wells, PL2-006AR and PL2-027A located in OA-11, Building 2-72 Area. Area is well delineated by multiple wells and probes. OA-11 has since been excavated to remove PCB source area soil and is anticipated to have improved groundwater conditions post-excavation.

Notes:

[a]Exceedance Area IDs presented on Figures 4-8D and 4-8E.

[b]Stability evaluated by comparing DGI and more recent data to historical data as presented in the DGI work plans

[c]PCBs will be analyzed annually. Continued PCB analyses will be evaluated after four annual shoreline monitoring events are completed.

Total PCB FMCL = 0.1 ug/L

Abbreviations:

CMS - Corrective Measures Study
DGI - Data Gaps Investigation
DP - Direct Push
FMCL - Final Media Cleanup Level
ID - Identification
OA - Other Area
PCB - Polychlorinated Biphenyls
PL2 - Boeing Plant 2
POC - Point of Compliance

Table 4-8: Cadmium FMCL Exceedances in Groundwater

Exceedance Area ID[a]	Aquifer Level	Concentration Range (ug/L)	Are Exceedances Present at the POC?	Wells Proposed for Monitoring	Stability Evaluation[b]	Comments
Cadmium-1	A	0.95	Yes, see comment	PL2-614A	Stable area with decreasing concentrations. Contaminated soil in SW Bank has been excavated.	Based on data from shoreline well PL2-614A from August 2016. Adjacent shallow soil was excavated and replaced with clean soil to create habitat.
Cadmium-2	A	0.3	No	None	Difficult to evaluate due to a lack of historical cadmium data in the immediate area.	Based on DGI data from well PL2-021A inside the 2-66 sheetpile. Well PL2-021A was decommissoned and soil from the interior of the sheetpile was excavated to and replaced with clean soil.
Cadmium-3	A	1.3	Yes, see comment	PL2-621A	Difficult to evaluate due to a lack of historical cadmium data.	Based on data from shoreline well PL2-621A. Historical cadmium detections in samples from surrounding probes are superseded by newer well data. In addition, potential soil source material in the area was excavated and replaced with clean soil
Cadmium-4	A	0.3 and 0.4	No	PL2-621A	Difficult to evaluate due to a lack of historical cadmium data.	Based on two probes, 2-40-DP-93 and 2-40-DP-94. Exceedance area is well delineated by non-detects in samples from surrounding probes. Exceedance was slightly greater than the FMCL and was from probe samples.
Cadmium-5	A	4	No	None	Difficult to evaluate due to a lack of historical cadmium data.	Based on DGI data from well PL2-440A. Exceedance area is well delineated by non-detects in samples from surrounding wells and probes.

Notes:

[a]Exceedance Area IDs presented on Figures 4-10D and 4-10E.

[b]Stability evaluated by comparing DGI and more recent data to historical data as presented in the DGI work plans.

[c]Statistical analyses performed with historical and new data after two sampling events to determine if continued monitoring is warranted.

Cadmium FMCL = 0.21 ug/L

Abbreviations:

CMS - Corrective Measures Study
DGI - Data Gaps Investigation
DP - Direct Push
FMCL - Final Media Cleanup Level
ID - Identification
NA - North Area
POC - Point of Compliance
SW - Southwest

Table 5-1: Soil and Groundwater Technology Screening

Technology	Screening Comments	Soil	Groundwater	Retained? Yes/No	CMS Attachment S5A-1 Section
CORRECTIVE ACTION NOT REQUIRED					
	Retained for areas of COPC exceedances that are not at or near the POC and are stable or shrinking.	X	X	Yes	1.1
MONITORING AND MONITORED NATURAL ATTENUATION					
	Required component of site remedies.	X	X	Yes	1.2
ENGINEERING CONTROLS					
Site Access Control Fencing	Effective, easy to implement, low cost.	X		Yes	1.3.1
Security patrols	Expensive and unnecessary. Facility currently has security controls, fencing, and signs.	X		No	1.3.1
Dust Control	Potentially necessary during excavation.	X		Yes	1.3.1
Surface Water Controls Grading Stormwater Drainage Controls Vegetative Cover	Proven technology, effective, easily implemented, and inexpensive.	X	X	Yes	1.3.1
Pavement (asphalt/concrete)	Paving is proven, effective technology for providing reliable long-term containment and preventing or minimizing off-site migration of COCs.	X		Yes	1.3.1
INSTITUTIONAL CONTROLS					
Environmental Covenants	Effective, easy to implement, cost uncertain (affects land value).	X		Yes	1.4.1
Groundwater Use Restrictions	There are existing groundwater use restrictions in place that prevent development of the aquifer for drinking water.		X	Yes	1.4.2
CONTAINMENT					
Physical Barriers	Effective for all COPCs. Above average reliability, average O&M intensity, and low cost relative to other remediation technologies. A proven remediation technology at Plant 2; however, the three existing sheetpiles at Plant 2 already contain groundwater that formerly had the greatest contaminant concentrations and there are no other areas where groundwater conditions warrant this technology.		X	No	1.5.2
Deep Well Injection	This remediation technique requires an underground injection control (UIC) permit from Ecology. Ecology will not allow injection of contaminated groundwater into deeper underlying aquifers because this use would violate Ecology's non-endangerment performance standard for underground injection wells.		X	No	1.5.2
IN-SITU BIOLOGICAL TREATMENT					
Bioventing	Effective, proven technology for treating mid-weight petroleum products (diesel and jet fuels). Heavy lubricating oils take longer to degrade.	X		Yes	1.6.1
Enhanced Reductive Dechlorination (ERD)	Effective for halogenated VOCs. Variable effectiveness for other COPC groups. Average reliability, high O&M intensity, and low cost relative to other remediation technologies. A proven remediation technology at Plant 2.		X	Yes	1.6.2
Enhanced Aerobic Degradation (EAD)	Effective for non-halogenated VOC and SVOCs, and fuels. Variable effectiveness for other COPC groups. Average reliability, high O&M intensity, and low cost relative to other remediation technologies. A proven remediation technology at Plant 2.		X	Yes	1.6.2
Monitored Natural Attenuation (MNA)	Effective for non-halogenated VOCs and fuels. Limited effectiveness for halogenated VOC and halogenated and non-halogenated SVOCs. Not effective for inorganics. Average reliability, high O&M intensity, and low cost relative to other remediation technologies. Not appropriate for exceedance areas that are at or near the POC and not needed for stable or shrinking exceedance areas inland of the POC.		X	No	1.6.2
Phytoremediation	Current and planned future land use at Plant 2 precludes the use of phytoremediation as a groundwater treatment technology. The site is currently paved and will remain paved in the foreseeable future, with the exception of habitat areas along the shoreline. The paving will prevent the use of plants to remediate shallow groundwater at the scale necessary to make this a viable remediation technology.		X	No	1.6.2
IN-SITU PHYSICAL/CHEMICAL TREATMENT					
Chemical Oxidation/Reduction	Not retained for further consideration because of physical constraints and difficultly in verifying treatment effectiveness.	X		No	1.6.3
SVE	Effective proven technology for lighter volatile compounds (GRPH). Not effective for heavier petroleum products (DRPH and ORPH).	X		Yes	1.6.3
Solidification	Difficult to implement in situ.	X		No	1.6.3
Air Sparging/SVE	Effective for non-halogenated VOCs and fuels. Limited effectiveness for halogenated VOC and halogenated and non-halogenated SVOCs. Not effective for inorganics. Above average reliability, low O&M intensity, and low cost relative to other remediation technologies. SVE operated in conjunction to remove vapors generated by air sparging.		X	Yes	1.6.4
Bioslurping	There are no known areas of LNAPL in Plant 2 that would make the use of this free product recovery technique appropriate. Bioslurping is not an appropriate technology for remediation of dissolved contaminants in groundwater		X	No	1.6.4

Table 5-1: Soil and Groundwater Technology Screening

Technology	Screening Comments	Soil	Groundwater	Retained? Yes/No	CMS Attachment S5A-1 Section
Chemical Oxidation (ChemOx)	Limited effectiveness for halogenated and non-halogenated VOCs and halogenated SVOCs. Not effective for other COPCs. Average reliability, high O&M intensity, and average cost relative to other remediation technologies. Plant 2 has naturally occurring anaerobic geochemistry and high concentrations of non-contaminant organics and reduced metals species, which would result in significant unproductive oxidant consumption.		X	No	1.6.4
Directional Wells (not a stand alone technology)	All areas of groundwater plumes that reach the POC are accessible to standard vertical drilling and probing techniques and directional drilling is not anticipated to be required at the site.		X	No	1.6.4
Dual Phase Extraction	There are no known areas of LNAPL that reach the POC in Plant 2 that would make the use of this free product recovery technique appropriate. Dual phase extraction is not an appropriate technology for remediation of dissolved contaminants in groundwater.		X	No	1.6.4
Hydrofracturing Enhancements (not a stand alone technology)	There are no low-permeability or over-consolidated formations that potentially require hydrofracturing to allow injection of remediation products or to enhance groundwater pumping efficiency. The aquifer is amenable to injection of remediation products and groundwater extraction without hydrofracturing enhancements.		X	No	1.6.4
In-Well Air Stripping, aka Density Driven Convection (DDC)	Limited effectiveness for halogenated and non-halogenated VOCs and non-halogenated SVOCs. Not effective for other COPCs. Average reliability, average O&M intensity, and average cost relative to other remediation technologies. DDC was effective as an interim measure at the 2-66 sheetpile but cVOC concentrations that make this technology applicable are no longer present in groundwater at Plant 2.		X	No	1.6.4
Permeable Reactive Barriers (PRBs)	Effective for halogenated and non-halogenated VOCs and SVOCs. Limited effectiveness for fuels. Not effective for other COPCs. Above average reliability, average O&M intensity, and average cost relative to other remediation technologies.		X	No	1.6.4
IN-SITU THERMAL TREATMENT					
Soil Thermal Treatment	Difficult to implement technically and administratively because of physical limits, permits, and public resistance.	X		No	1.6.5, 1.7.5
Groundwater Thermal Treatment	Effective for halogenated and non-halogenated SVOCs. Limited effectiveness for VOCs because there are more effective remediation technologies for VOCs. Ineffective for inorganics. Average reliability, high O&M intensity, and average cost relative to other remediation technologies.		X	No	1.6.6
EX-SITU BIOLOGICAL TREATMENT					
Biopiles Composting Landfarming Slurry phase Biological Treatment	Not effective on many constituents of potential concern, such as chlorinated organic compounds and metals.	X		No	1.7.1
Bioreactors	Effective for halogenated and non-halogenated VOCs and non-halogenated SVOCs. Limited effectiveness for fuels. Not effective for other COPCs. Average reliability, average O&M intensity, and low cost relative to other remediation technologies. Requires groundwater pumping and is most effective for conditions of high contaminant concentrations within a limited aerial extent. These conditions are not present at Plant 2, which significantly limits the applicability of this technology.		X	No	1.7.2
Constructed Wetlands	Current and planned future land use at Plant 2 precludes the use of constructed wetlands as a groundwater treatment technology. The site is currently paved and will remain paved in the foreseeable future, with the exception of habitat areas along the shoreline. The current and planned future land uses prevent the implementation of constructed wetlands at a large enough scale to effectively remediate groundwater at Plant 2.		X	No	1.7.2
EX-SITU PHYSICAL/CHEMICAL TREATMENT					
Reuse/Recycling	Excavated soils may be reused or recycled used as landfill cap material.	X		Yes	1.7.3
Dry Soil Sieving	Site soil is primarily fine sands and silt. The physical characteristics do not lend themselves to efficient physical separation and volume reduction.	X		No	1.7.3
Physical Soil Washing	Not an established technology; difficult to implement due to the complexity and site constraints, unlikely to be cost-effective.	X		No	1.7.3
Chemical Extraction	Unproven; may not be effective at this site; difficult to implement; costly.	X		No	1.7.3
Chemical Oxidation/Reduction	Unproven; may not be effective for site soil constituents of concern; other technologies are equally effective and less costly.	X		No	1.7.3
Solidification	Proven, effective treatment for metals and PCBs; relatively easy to implement; moderate cost. Data indicate soil is not impacted with PCBs and metals above FMCLs. This technology may be used if needed to meet waste disposal requirements.	X		No	1.7.3

Table 5-1: Soil and Groundwater Technology Screening

Technology	Screening Comments	Soil	Groundwater	Retained? Yes/No	CMS Attachment S5A-1 Section
Adsorption/Absorption	Effective for inorganics. Limited effectiveness for halogenated and non-halogenated VOCs and SVOCs. Not effective for fuels. Average reliability, high O&M intensity, and high cost relative to other remediation technologies. This technology requires groundwater pumping and is not efficient for low concentration exceedances over a large aerial extent, which is the case for most COPCs at Plant 2.		X	No	1.7.4
Advanced Oxidation Processes / Ultraviolet (UV) Oxidation	Effective for halogenated and non-halogenated VOCs and SVOCs, and fuels. Effectiveness highly variable for inorganics. Average reliability, high O&M intensity, and average cost relative to other remediation technologies. This technology requires groundwater pumping and is not efficient for low concentration exceedances over a large aerial extent, which is the case for most COPCs at Plant 2.		X	No	1.7.4
Air Stripping	Effective for halogenated and non-halogenated VOCs, Not effective for other COPCs. Above average reliability, high O&M intensity, and low cost relative to other remediation technologies. This technology requires groundwater pumping. More effective technologies exist for organics and air stripping is not effective for inorganics, which significantly limits its potential use at Plant 2.		X	No	1.7.4
Granular Activated Carbon (GAC)	Effective for halogenated and non-halogenated VOCs and SVOCs, and fuels. Effectiveness highly variable for inorganics. Above average reliability, high O&M intensity, and average cost relative to other remediation technologies. This technology requires groundwater pumping. More effective technologies exist for organics and GAC is not effective for many inorganics, which significantly limits its potential use at Plant 2.		X	No	1.7.4
Ion Exchange	Effective for inorganics. Limited effectiveness for halogenated and non-halogenated VOCs and SVOCs, and fuels. Above average reliability, high O&M intensity, and high average cost relative to other remediation technologies. This technology requires groundwater pumping and is not efficient for low concentration exceedances over a large aerial extent, which is the case for most COPCs at Plant 2.		X	No	1.7.4
Precipitation/Coagulation/ Flocculation	Effective for inorganics. Limited effectiveness for halogenated and non-halogenated VOCs and SVOCs, and fuels. Above average reliability, average O&M intensity, and average cost relative to other remediation technologies. This technology requires groundwater pumping and is a proven, reliable, and potentially cost effective technology for inorganics treatment.		X	Yes	1.7.4
Separation	Effective for halogenated and non-halogenated VOCs and SVOCs, and fuels. Effectiveness highly variable for inorganics. Above average reliability, high O&M intensity, and high cost relative to other remediation technologies. This technology requires groundwater pumping. More effective technologies exist for organics and separation is not effective for many inorganics, which significantly limits its potential use at Plant 2.		X	No	1.7.4
Sprinkler Irrigation	This remediation technique releases stripped VOCs directly to the atmosphere, which is an unacceptable practice for the chlorinated VOC contaminants that are the target contaminants for this remediation technology.		X	No	1.7.4
EX-SITU THERMAL TREATMENT					
Incineration	Proven, effective treatment for organic waste. High cost. Data does not show sufficient concentrations or volume of soil exceeding FMCLs to support this technology. This technology may be used if needed to meet waste disposal requirements.	X		No	1.7.5
Thermal Desorption	Proven, effective treatment for organic waste. Data does not show sufficient concentrations or volume of soil exceeding FMCLs to support this technology. This technology may be used if needed to meet waste disposal requirements.	X		No	1.7.5
Vitrification	Not cost effective.	X		No	1.7.5
REMOVAL					
Excavation (soil/waste)	Effective, easily implemented, and cost effective. Issues to be addressed during excavation include: (1) stability of the excavation, (2) worker exposure, and (3) mobilization of constituents of concern.	X	X	Yes	1.8.1, 1.8.2
DISPOSAL					
On-site Constructed Landfill	On-site containment is not retained because of physical constraints and land use restrictions at the site.	X		No	1.9
Off-site Permitted Solid Waste Landfill	Feasible, proven technology for mixed waste.	X	X	Yes	1.9

Table 5-2: Technologies Retained for Alternative Evaluation

Technology Type	Options
Soil	
Corrective Action Not Required	
Monitoring	Monitored Natural Attenuation (MNA)
Engineering Controls	Site Access Control
	Dust Control
	Surface Water Controls (Grading, Stormwater Drainage Controls, Vegetative Cover)
	Pavement (for stormwater control)
Institutional Controls	Environmental Covenants
	Groundwater Use Restrictions
In-Situ Soil Treatment	Bioventing
	SVE
Ex Situ Soil Treatments	Reuse/Recycling
Removal	Excavation
Disposal	Permitted Solid Waste Landfill
	Permitted Hazardous Waste and/or Toxic Substances Control Act (TSCA) Landfill
Groundwater	
Corrective Action Not Required	
In-Situ Biological Treatment	Enhanced Reductive Dechlorination (ERD)
	Enhanced Aerobic Degradation (EAD)
In-Situ Physical / Chemical Treatment	Air Sparging (AS)
Ex Situ Physical / Chemical Treatment (assumes pumping)	Precipitation / Coagulation / Flocculation
Impacted Soil Removal	Soil Excavation

Table 6-1A: RA 1 - 2-10 North Sheetpile Area Applicable Technologies

FMCL Exceedance Area	Associated RCRA Unit	Description	Maximum COC Exceedance Factor									Applicable Remedial Technologies								
			Organics			Inorganics				TPH		Soil and Groundwater					Groundwater			
			cVOCs (TCE, cDCE, VC)	PCBs	cPAH	Arsenic	Copper and Zinc	Cadmium	Cyanide	Benzene, Ethylbenzene, GRPH	DRPH, MoRPH, Naphthalene	Corrective Action Not Required	Engineering Controls (Site Access, Surface Water Controls, and Paving)	Institutional Controls (Land Use Restrictions)	Long-term Groundwater Monitoring	Excavation with Off-Site Disposal	Short-term Groundwater Monitoring	Enhanced Reductive Dechlorination (ERD)	Adaptive Management for Inorganics	Adaptive Management for Organics
RA 1 – 2-10 North Sheetpile (Soil - Direct Contact)																				
Soil Sample Locations (PL2-SSL2, PL2-212A, and PL2-212B)	AOC-2-10.3A North Sheetpile		2.5									X	X	X	X	X				
RA 1 – 2-10 North Sheetpile (Groundwater)																				
cVOC-15	AOC-2-10.3A North Sheetpile	A-Level TCE, cDCE, and VC	6K										X	X	X	X		X		X
cVOC-16		B-Level cDCE and VC	1.7										X	X	X			X		X
Arsenic-9		A-Level Arsenic				4.9							X	X	X				X	
Arsenic-12						6.0							X	X	X				X	
CuZn-16		A-Level Copper					2.2						X	X	X				X	

Abbreviations:

AOC - Area of Concern
cDCE - cis-1,2-Dichloroethene
COC - Constituent of Concern
cPAH - Carcinogenic Polycyclic Aromatic Hydrocarbons
CuZn - Copper and Zinc
cVOC - Chlorinated Volatile Organic Compound
DRPH - Diesel Range Petroleum Hydrocarbons
FMCL - Final Media Cleanup Level
GRPH - Gasoline Range Petroleum Hydrocarbons
MoRPH - Motor Oil Range Petroleum Hydrocarbons
PCBs - Polychlorinated Biphenyls
RCRA - Resource Conservation and Recovery Act
TCE - Trichloroethene
TPH - Total Petroleum Hydrocarbon
VC - Vinyl Chloride

Notes:

1. The soil leaching pathway evaluates soil concentrations in the 6 to 11 ft bgs depth range with groundwater concentrations.
2. Maximum COC Exceedance Factor (unit less) = Maximum COC Concentration / FMCL value
3. Empty cells in the Maximum COC Exceedance Factor indicate constituents that are not COCs in the RA.

Table 6-1B: RA 1 - 2-10 North Sheetpile Area Alternatives

Alternatives			Alternatives for Organics														Alternatives for Inorganics In Groundwater	Alternatives for Organics In Groundwater
			1			2					2a							
			Corrective Action Not Required with Controls			Enhanced Reductive Dechlorination (ERD)					ERD and Excavation with Off-Site Disposal						AM-1	AM-2
Technologies			Corrective Action Not Required	Engineering Controls	Institutional Controls	Engineering Controls	Institutional Controls	Long-term Groundwater Monitoring	Short-term Groundwater Monitoring	Enhanced Reductive Dechlorination (ERD)	Engineering Controls	Institutional Controls	Long-term Groundwater Monitoring	Short-term Groundwater Monitoring	Enhanced Reductive Dechlorination (ERD)	Excavation to Direct Contact	Adaptive Management	Adaptive Management
FMCL Exceedance Area	**Associated RCRA Unit**	**Description**																
RA 1 – 2-10 North Sheetpile (Soil > FMCLs)																		
Soil Sample Locations (PL2-SSL2, PL2-212A, and PL2-212B)	AOC-2-10.3A North Sheetpile	TCE	X	X	X	X	X	X			X	X	X			X		
RA 1 – 2-10 North Sheetpile (Groundwater > FMCLs)																		
cVOC-15	AOC-2-10.3A North Sheetpile	A-Level TCE, cDCE, and VC		X	X	X	X	X		X	X	X	X		X	X		X
cVOC-16		B-Level cDCE and VC		X	X	X	X	X		X	X	X	X		X			X
Arsenic-9		A-Level Arsenic		X	X	X	X	X			X	X	X				X	
Arsenic-12				X	X	X	X	X			X	X	X				X	
CuZn-16		A-Level Copper		X	X	X	X	X			X	X	X				X	

Abbreviations:

AOC - Area of Concern
cDCE - cis-1,2-Dichloroethene
CuZn - Copper and Zinc
cVOC - Chlorinated Volatile Organic Compound
FMCL - Final Media Cleanup Level
RCRA - Resource Conservation and Recovery Act
SVE - Soil Vapor Extraction
TCE - Trichloroethene
VC - Vinyl Chloride

Table 6-1C: RA 1 - 2-10 North Sheetpile Area Evaluation of Alternatives

RCRA Alternative Evaluation Standards	Alternatives for Organics			Alternatives for Inorganics and Organics in Groundwater
	1	2	2a	AM-1 or AM-2
	Corrective Action Not Required (with Controls)	Enhanced Reductive Dechlorination	Enhanced Reductive Dechlorination With Excavation	Adaptive Management
Determining Whether Alternative Complies with the Standards	**Ratings are Low = 1, Medium Low = 2, Medium = 3 Medium High = 4 and High = 5**			
Protect Human Health and the Environment	Yes	Yes	Yes	Yes
Attain FMCLs	Yes	Yes	Yes	Yes
Control Source of the Releases	Yes	Yes	Yes	Yes
Comply with Applicable Standards (With or Without Waivers)	Yes	Yes	Yes	Yes
Other Factors				
Long-term Reliability and Effectiveness	2	4	5	TBD
Reduction in Toxicity, Mobility, or Volume of Waste	2	5	4	TBD
Short-term Effectiveness	5	4	3	TBD
Implementability	5	4	2	TBD
Cost Effectiveness	5	4	3	TBD
Restoration Timeframe	2	4	5	TBD
Total Net Benefit	21	25	22	NA
Recommended Alternative - 2 Enhanced Reductive Dechlorination (with Monitoring and Controls)				

Notes:
The existing sheetpile and building slab would need to be maintained until compliance is reached.
Yes - Indicates that the alternative at a minimum meets the RCRA standard.
TBD - To be determined (if needed), actual technology is dependent on site conditions and constituent(s) following implementation of recommended alternative.

Table 6-2A: RA 2 - 2-10 South Sheetpile Area Applicable Technologies

FMCL Exceedance Area	Associated RCRA Unit	Description	Maximum COC Exceedance Factor									Applicable Remedial Technologies									
			Organics			Inorganics				TPH		Soil and Groundwater					Groundwater				
			cVOCs (TCE, cDCE, VC)	PCBs	cPAH	Arsenic	Copper and Zinc	Cadmium	Cyanide	Benzene, Ethylbenzene, GRPH	DRPH, MoRPH, Naphthalene	Corrective Action Not Required	Engineering Controls (Site Access, Surface Water Controls, and Paving)	Institutional Controls (Land Use Restrictions)	Long-term Groundwater Monitoring	Excavation with Off-Site Disposal	Short-term Groundwater Monitoring	Enhanced Reductive Dechlorination (ERD)	Air Sparging/SVE	Adaptive Management for Inorganics	Adaptive Management for Organics
RA 2 – 2-10 South Sheetpile (Soil Direct Contact)																					
Soil Sample Location (PL2-209A)	AOC-2-10.4A South TCE Degreaser	TCE	1.4									X	X	X	X	X					
RA 2 – 2-10 South Sheetpile (Groundwater)																					
cVOC-13	AOC-2-10.4A South TCE Degreaser	A-Level TCE and VC	51										X	X	X			X	X		X
cVOC-14		B-Level TCE	13										X	X	X						X
Arsenic-6		A-Level Arsenic				6.1							X	X	X					X	
CuZn-14		B-Level Zinc					1.1						X	X	X					X	
CuZn-15		A-Level Copper					2.0						X	X	X					X	

Abbreviations:

AOC - Area of Concern
cDCE - cis-1,2-Dichloroethene
COC - Constituent of Concern
cPAH - Carcinogenic Polycyclic Aromatic Hydrocarbons
CuZn - Copper and Zinc
cVOC - Chlorinated Volatile Organic Compound
DRPH - Diesel Range Petroleum Hydrocarbons
FMCL - Final Media Cleanup Level
GRPH - Gasoline Range Petroleum Hydrocarbons
MoRPH - Motor Oil Range Petroleum Hydrocarbons
PCBs - Polychlorinated Biphenyls
RCRA - Resource Conservation and Recovery Act
SVE - Soil Vapor Extraction
TCE - Trichloroethene
TPH - Total Petroleum Hydrocarbon
VC - Vinyl Chloride

Notes:

1. The soil leaching pathway evaluates soil concentrations in the 6 to 11 ft bgs depth range with groundwater concentrations.
2. Maximum COC Exceedance Factor (unit less) = Maximum COC Concentration / FMCL value
3. Empty cells in the Maximum COC Exceedance Factor indicate constituents that are not COCs in the RA.

Table 6-2B: RA 2 - 2-10 South Sheetpile Area Alternatives

Alternatives			Alternatives for Organics														Alternatives for Inorganics In Groundwater	Alternatives for Organics In Groundwater
			1			2					2a							
			Corrective Action Not Required with Controls			Enhanced Reductive Dechlorination (ERD)					ERD and Excavation with Off-Site Disposal						AM-1	AM-2
Technologies			Corrective Action Not Required	Engineering Controls	Institutional Controls	Engineering Controls	Institutional Controls	Long-term Groundwater Monitoring	Short-term Groundwater Monitoring	Enhanced Reductive Dechlorination (ERD)	Engineering Controls	Institutional Controls	Long-term Groundwater Monitoring	Short-term Groundwater Monitoring	Enhanced Reductive Dechlorination (ERD)	Excavation to Direct Contact	Adaptive Management	Adaptive Management
FMCL Exceedance Area	**Associated RCRA Unit**	**Description**																
RA 2 – 2-10 South Sheetpile (Soil >FMCLs)																		
Soil Sample Location (PL2-209A)	AOC-2-10.4A South TCE Degreaser		X	X	X	X	X	X	X		X	X	X	X		X		
RA 2 – 2-10 South Sheetpile (Groundwater > FMCLs)																		
cVOC-13	AOC-2-10.4A South TCE Degreaser	A-Level TCE and VC		X	X	X	X	X		X	X	X	X		X			X
cVOC-14		B-Level TCE		X	X	X	X	X		X	X	X	X		X			X
Arsenic-6		A-Level Arsenic		X	X	X	X	X			X	X	X				X	
CuZn-14		B-Level Zinc		X	X	X	X	X			X	X	X				X	
CuZn-15		A-Level Copper		X	X	X	X	X			X	X	X				X	

Abbreviations:

AOC - Area of Concern
cDCE - cis-1,2-Dichloroethene
CuZn - Copper and Zinc
cVOC - Chlorinated Volatile Organic Compound
FMCL - Final Media Cleanup Level
RCRA - Resource Conservation and Recovery Act
SVE- Soil Vapor Extraction
TCE - Trichloroethene
VC - Vinyl Chloride

Table 6-2C: RA 2 - 2-10 South Sheetpile Area Evaluation of Alternatives

RCRA Alternative Evaluation Standards	Alternatives for Organics			Alternatives for Inorganics and Organics in Groundwater
	1	2	2a	AM-1 or AM-2
	Corrective Action Not Required (with Controls)	Enhanced Reductive Dechlorination	Enhanced Reductive Dechlorination With Excavation	Adaptive Management
Determining Whether Alternative Complies with the Standards	**Ratings are Low = 1, Medium Low = 2, Medium = 3 Medium High = 4 and High = 5**			
Protect Human Health and the Environment	Yes	Yes	Yes	Yes
Attain FMCLs	Yes	Yes	Yes	Yes
Control Source of the Releases	Yes	Yes	Yes	Yes
Comply with Applicable Standards (With or Without Waivers)	Yes	Yes	Yes	Yes
Other Factors				
Long-term Reliability and Effectiveness	2	4	5	TBD
Reduction in Toxicity, Mobility, or Volume of Waste	2	5	4	TBD
Short-term Effectiveness	5	4	3	TBD
Implementability	5	4	2	TBD
Cost Effectiveness	5	4	3	TBD
Restoration Timeframe	2	4	5	TBD
Total Net Benefit	21	25	22	NA
Recommended Alternative - 2 Enhanced Reductive Dechlorination (with Monitoring and Controls)				

Notes:
The existing sheetpile and building slab would need to be maintained until compliance is reached.
Yes - Indicates that the alternative at a minimum meets the RCRA standard.
TBD - To be determined (if needed), actual technology is dependent on site conditions and constituent(s) following implementation of recommended alternative.

Table 6-3A: RA 3 - 2-31 Area Applicable Technologies

FMCL Exceedance Area	Associated RCRA Unit	Description	Maximum COC Exceedance Factor									Applicable Remedial Technologies									
			Organics			Inorganics				TPH		Soil and Groundwater					Groundwater*				
			cVOCs (TCE, cDCE, VC)	PCBs	cPAH	Arsenic	Copper and Zinc	Cadmium	Cyanide	Benzene, Ethylbenzene, GRPH	DRPH, MoRPH, Naphthalene	Corrective Action Not Required	Engineering Controls (Site Access, Surface Water Controls, and Paving)	Institutional Controls (Land Use Restrictions)	Long-term Groundwater Monitoring	Excavation with Off-Site Disposal	Short-term Groundwater Monitoring	Enhanced Reductive Dechlorination (ERD)	Air Sparging/SVE	Adaptive Management for Inorganics	Adaptive Management for Organics
RA 3 – 2-31 Area (Soil																					
RA 3 – 2-31 Area (Groundwater)																					
cVOC-10	AOC 2-31.21 TCE Degreaser	A-Level TCE, cDCE, and VC	20K										X	X	X			X	X		X
cVOC-11		B-Level VC	2.8										X	X	X			X	X		X
Arsenic-4	None	A-Level Arsenic				5.2							X	X	X					X	
Arsenic-5						1.6							X	X	X					X	
CuZn-10		B-Level Zinc					3.4						X	X	X					X	
Cadmium-3		A-Level Cadmium						6.2					X	X	X					X	
Cadmium-4								1.9					X	X	X					X	

Abbreviations:

AOC - Area of Concern
cDCE - cis-1,2-Dichloroethene
COC - Constituent of Concern
cPAH - Carcinogenic Polycyclic Aromatic Hydrocarbons
CuZn - Copper and Zinc
cVOC - Chlorinated Volatile Organic Compound
DRPH - Diesel Range Petroleum Hydrocarbons
FMCL - Final Media Cleanup Level
GRPH - Gasoline Range Petroleum Hydrocarbons
MoRPH - Motor Oil Range Petroleum Hydrocarbons
PCBs - Polychlorinated Biphenyls
RCRA - Resource Conservation and Recovery Act
SVE - Soil Vapor Extraction
TCE - Trichloroethene
TPH - Total Petroleum Hydrocarbon
VC - Vinyl Chloride

Notes:

1. The soil leaching pathway evaluates soil concentrations in the 6 to 11 ft bgs depth range with groundwater concentrations.
2. Maximum COC Exceedance Factor (unit less) = Maximum COC Concentration / FMCL value
3. Empty cells in the Maximum COC Exceedance Factor indicate constituents that are not COCs in the RA.

* Adaptive Management for PCBs may be implemented in the future if required as outlined in Section 6.8.

Table 6-3B: RA 3 - 2-31 Area Alternatives

Alternatives*			Alternatives for Organics													Alternatives for Inorganics In Groundwater	Alternatives for Organics In Groundwater
			1			2					3						
			Corrective Action Not Required with Controls			Enhanced Reductive Dechlorination (ERD)					Air Sparging / Soil Vapor Extraction					AM-1	AM-2
Technologies			Corrective Action Not Required	Engineering Controls	Institutional Controls	Engineering Controls	Institutional Controls	Long-term Groundwater Monitoring	Short-term Groundwater Monitoring	Enhanced Reductive Dechlorination (ERD)	Engineering Controls	Institutional Controls	Long-term Groundwater Monitoring	Short-term Groundwater Monitoring	Air Sparging/SVE	Adaptive Management	Adaptive Management
FMCL Exceedance Area	**Associated RCRA Unit**	**Description**															
RA 3 – 2-31 Area (Groundwater > FMCLs)																	
cVOC-10	AOC 2-31.21 TCE Degreaser	A-Level TCE, cDCE, and VC		X	X	X	X	X		X	X	X	X		X		X
cVOC-11	None	B-Level VC		X	X	X	X	X		X	X	X	X		X		X
Arsenic-4	None	A-Level Arsenic		X	X	X	X	X			X	X	X			X	
Arsenic-5				X	X	X	X	X			X	X	X			X	
CuZn-10	None	B-Level Zinc		X	X	X	X	X			X	X	X			X	
Cadmium-3	None	A-Level Cadmium		X	X	X	X	X			X	X	X			X	
Cadmium-4				X	X	X	X	X			X	X	X			X	

Abbreviations:

AOC - Area of Concern
cDCE - cis-1,2-Dichloroethene
CuZn - Copper and Zinc
cVOC - Chlorinated Volatile Organic Compound
FMCL - Final Media Cleanup Level
PCBs - Polychlorinated Biphenyls
RCRA - Resource Conservation and Recovery Act
SVE - Soil Vapor Extraction
TCE - Trichloroethene
VC - Vinyl Chloride

Notes:

* Alternative AM-3 Adaptive Management for PCBs may be implemented in the future if required as outlined in Section 6.8

Table 6-3C: RA 3 - 2-31 Area Evaluation of Alternatives

RCRA Alternative Evaluation Standards	Alternatives for Organics			Alternatives for Organics, Inorganics, and PCBs in Groundwater
	1	2	3	AM-1, AM-2, or AM-3
	Corrective Action Not Required (with Controls)	Enhanced Reductive Dechlorination	Air Sparging/SVE	Adaptive Management
Determining Whether Alternative Complies with the Standards	**Ratings are Low = 1, Medium Low = 2, Medium = 3 Medium High = 4 and High = 5**			
Protect Human Health and the Environment	Yes	Yes	Yes	Yes
Attain FMCLs	Yes	Yes	Yes	Yes
Control Source of the Releases	Yes	Yes	Yes	Yes
Comply with Applicable Standards (With or Without Waivers)	Yes	Yes	Yes	Yes
Other Factors				
Long-term Reliability and Effectiveness	2	4	4	TBD
Reduction in Toxicity, Mobility, or Volume of Waste	2	5	3	TBD
Short-term Effectiveness	5	4	3	TBD
Implementability	5	4	3	TBD
Cost Effectiveness	5	4	3	TBD
Restoration Timeframe	2	4	4	TBD
Total Net Benefit	21	25	20	NA
Recommended Alternative - 2 Enhanced Reductive Dechlorination (with Monitoring and Controls)				

Notes:
Yes - Indicates that the alternative at a minimum meets the RCRA standard.
TBD - To be determined (if needed), actual technology is dependent on site conditions and constituent(s) following implementation of recommended alternative.

Table 6-4A: RA 4 - 2-66 Sheetpile and Surrounding Area Applicable Technologies

FMCL Exceedance Area	Associated RCRA Unit	Description	Maximum COC Exceedance Factor									Applicable Remedial Technologies										
			Organics			Inorganics				TPH		Soil and Groundwater					Groundwater*					
			cVOCs (TCE, cDCE, VC)	PCBs	cPAH	Arsenic	Copper and Zinc	Cadmium	Cyanide	Benzene, Ethylbenzene, GRPH	DRPH, MoRPH, Naphthalene	Corrective Action Not Required	Engineering Controls (Site Access, Surface Water Controls, and Paving)	Institutional Controls (Land Use Restrictions)	Long-term Groundwater Monitoring	Excavation with Off-Site Disposal	Short-term Groundwater Monitoring	Enhanced Reductive Dechlorination (ERD)	Enhanced Aerobic Degradation (EAD)	Air Sparging/SVE	Adaptive Management for Inorganics	Adaptive Management for Organics
RA 4 – 2-66 Sheetpile and Surrounding Area (Soil does not exceed Direct Contact FMCLs)																						
RA 4 – 2-66 Sheetpile and Surrounding Area (Groundwater)																						
cVOC-4	OA-1 Building 2-66 Southwest and AOC 2-66.53 TCE Degreaser	B-Level VC	88										X	X	X			X		X		X
cVOC-5		A-Level TCE, cDCE, and VC	5K										X	X	X	X		X		X		X
cVOC-6		B-Level TCE and VC	26										X	X	X			X		X		X
BTEX-4	Former Diesel UST	A-Level Benzene and Ethylbenzene								7.6			X	X	X				X	X		X
BTEX-5	OA-9 Former USTs PL16, 17, 18 and SWMU 2-78.6 Oil Water Separator									118			X	X	X				X	X		X
DRPH-3	Former Diesel UST	A-Level DRPH and MoRPH									22		X	X	X				X	X		X
DRPH-5	OA-9 Former USTs PL16, 17, 18 and SWMU 2-78.6 Oil Water Separator	A-Level Naphthalene									24		X	X	X				X	X		X
Arsenic-2	None	A-Level Arsenic				2.3							X	X	X						X	
CuZn-2	OA-2 Building 2-66 Soil	A-Level Zinc					5.4						X	X	X						X	
CuZn-4							9.8						X	X	X						X	
CuZn-5		A-Level Copper and Zinc					10.4						X	X	X						X	
CuZn-6		C-Level Copper					1.8					X	X	X								
CuZn-7		B-Level Zinc					1.2						X	X	X						X	
Cadmium-1	OA-1 Building 2-66 Southwest	A-Level Cadmium						4.5					X	X							X	
Cadmium-2								1.4				X	X	X								
Cyanide-4	OA-2 Building 2-66 Soil	B-Level Cyanide							6.0			X	X	X								
Cyanide-5		A-Level Cyanide							5.0				X	X	X		X				X	

Abbreviations:

AOC - Area of Concern
BTEX - Benzene, Toluene, Ethylbenzene & Xylenes
cDCE - cis-1,2-Dichloroethene
COC - Constituent of Concern
cPAH - Carcinogenic Polycyclic Aromatic Hydrocarbons
CuZn - Copper and Zinc
cVOC - Chlorinated Volatile Organic Compound
DRPH - Diesel Range Petroleum Hydrocarbons
FMCL - Final Media Cleanup Level
GRPH - Gasoline Range Petroleum Hydrocarbons
MoRPH - Motor Oil Range Petroleum Hydrocarbons
OA - Other Area
PCBs - Polychlorinated Biphenyls
RCRA - Resource Conservation and Recovery Act
SVE - Soil Vapor Extraction
SWMU - Solid Waste Management Unit
TCE - Trichloroethene
TPH - Total Petroleum Hydrocarbon
UST - Underground Storage Tank
VC - Vinyl Chloride

Notes:

1. The soil leaching pathway evaluates soil concentrations in the 6 to 11 ft bgs depth range with groundwater concentrations.
2. Maximum COC Exceedance Factor (unit less) = Maximum COC Concentration / FMCL value
3. Empty cells in the Maximum COC Exceedance Factor indicate constituents that are not COCs in the RA.

* Adaptive Management for PCBs may be implemented in the future if required as outlined in Section 6.9.

Table 6-4B: RA 4 - 2-66 Sheetpile and Surrounding Area Alternatives

Alternatives*			Alternatives for Organics																										Alternatives for Inorganics In Groundwater	Alternatives for Organics In Groundwater
			1			2					2a						3					3a						AM-1	AM-2
			Corrective Action Not Required with Controls			Enhanced Reductive Dechlorination (ERD)					ERD and Excavation with Off Site Disposal						Air Sparging / Soil Vapor Extraction					Air Sparging / Soil Vapor Extraction with Off-Site Disposal							
Technologies			Corrective Action Not Required	Engineering Controls	Institutional Controls	Engineering Controls	Institutional Controls	Long-term Groundwater Monitoring	Short-term Groundwater Monitoring	Enhanced Reductive Dechlorination (ERD)	Engineering Controls	Institutional Controls	Long-term Groundwater Monitoring	Short-term Groundwater Monitoring	Enhanced Reductive Dechlorination (ERD)	Excavation to Direct Contact	Engineering Controls	Institutional Controls	Long-term Groundwater Monitoring	Short-term Groundwater Monitoring	Air Sparging/SVE	Engineering Controls	Institutional Controls	Long-term Groundwater Monitoring	Short-term Groundwater Monitoring	Air Sparging/SVE	Excavation to Direct Contact	Adaptive Management	Adaptive Management
FMCL Exceedance Area	**Associated RCRA Unit**	**Description**																											
RA 4 – 2-66 Sheetpile and Surrounding Area (Groundwater > FMCLs)																													
cVOC-4	OA-1 Building 2-66 Southwest and AOC 2-66.53 TCE Degreaser	B-Level VC		X	X	X	X	X		X	X	X	X		X		X	X	X		X	X	X	X		X			X
cVOC-5		A-Level TCE, cDCE, and VC		X	X	X	X	X		X	X	X	X		X	X	X	X	X		X	X	X	X		X	X		X
cVOC-6		B-Level TCE and VC		X	X	X	X	X		X	X	X	X		X		X	X	X		X	X	X	X		X			X
BTEX-4	Former Diesel UST	A-Level Benzene and Ethylbenzene		X	X	X	X	X			X	X	X				X	X	X		X	X	X	X		X			X
BTEX-5	OA-9 Former USTs PL16, 17, 18 and SWMU 2-78.6 Oil Water Separator			X	X	X	X	X			X	X	X				X	X	X		X	X	X	X		X			X
DRPH-3	Former Diesel UST	A-Level DRPH and MoRPH		X	X	X	X	X			X	X	X				X	X	X			X	X	X					X
DRPH-5	OA-1 Building 2-66 Southwest	A-Level Naphthalene	X	X	X	X	X				X	X					X	X				X	X						X
Arsenic-2	None	A-Level Arsenic		X	X	X	X	X			X	X	X				X	X	X			X	X	X				X	
CuZn-2	OA-2 Building 2-66 Soil	A-Level Zinc		X	X	X	X	X			X	X	X				X	X	X			X	X	X				X	
CuZn-4				X	X	X	X	X			X	X	X				X	X	X			X	X	X				X	
CuZn-5		A-Level Copper and Zinc		X	X	X	X	X			X	X	X				X	X	X			X	X	X				X	
CuZn-6		C-Level Copper	X	X	X	X	X				X	X					X	X				X	X						
CuZn-7		B-Level Zinc		X	X	X	X	X			X	X					X	X				X	X					X	
Cadmium-1	OA-1 Building 2-66 Southwest	A-Level Cadmium		X	X	X	X				X	X					X	X				X	X					X	
Cadmium-2			X	X	X	X	X				X	X					X	X				X	X						
Cyanide-4	OA-2 Building 2-66 Soil	B-Level Cyanide	X	X	X	X	X				X	X					X	X				X	X						
Cyanide-5		A-Level Cyanide		X	X	X	X	X	X		X	X	X	X			X	X	X	X		X	X	X	X			X	

Abbreviations:

AOC - Area of Concern
BTEX - Benzene, toluene, ethylbenzene, xylene
cDCE - cis-1,2-Dichloroethene
CuZn - Copper and Zinc
cVOC - Chlorinated Volatile Organic Compound
DRPH - Diesel Range Petroleum Hydrocarbons
FMCL - Final Media Cleanup Level
GRPH - Gasoline Range Petroleum Hydrocarbons
NAPH - Naphthalene
OA - Other Area
PCBs - Polychlorinated Biphenyls
RCRA - Resource Conservation and Recovery Act
SWMU - Solid Waste Management Unit
TCE - Trichloroethene
VC - Vinyl Chloride

Notes:

* Alternative AM-3 Adaptive Management for PCBs may be implemented in the future if required as outlined in Section 6.9.

Table 6-4C: RA 4 - 2-66 Sheetpile and Surrounding Area Evaluation of Alternatives

RCRA Alternative Evaluation Standards	Alternatives for Organics					Alternatives for Organics, Inorganics, and PCBs in Groundwater
	1	2	2a	3	3a	AM-1, AM-2, or AM-3
	Corrective Action Not Required (with Controls)	Enhanced Reductive Dechlorination	Enhanced Reductive Dechlorination with Excavation	Air Sparging/SVE	Air Sparging/SVE with Excavation	Adaptive Management
Determining Whether Alternative Complies with the Standards	**Ratings are Low = 1, Medium Low = 2, Medium = 3 Medium High = 4 and High = 5**					
Protect Human Health and the Environment	Yes	Yes	Yes	Yes	Yes	Yes
Attain FMCLs	Yes	Yes	Yes	Yes	Yes	Yes
Control Source of the Releases	Yes	Yes	Yes	Yes	Yes	Yes
Comply with Applicable Standards (With or Without Waivers)	Yes	Yes	Yes	Yes	Yes	Yes
Other Factors						
Long-term Reliability and Effectiveness	2	4	5	3	4	TBD
Reduction in Toxicity, Mobility, or Volume of Waste	2	5	4	3	3	TBD
Short-term Effectiveness	5	4	3	4	3	TBD
Implementability	5	4	4	3	3	TBD
Cost Effectiveness	5	4	3	3	2	TBD
Restoration Timeframe	2	4	5	4	4	TBD
Total Net Benefit	21	25	24	20	19	NA
Recommended Alternative - 2 Enhanced Reductive Dechlorination (with Monitoring and Controls)						

Notes:
Yes - Indicates that the alternative at a minimum meets the RCRA standard.
TBD - To be determined (if needed), actual technology is dependent on site conditions and constituent(s) following implementation of recommended alternative.

Table 6-5A: RA 5 - South Yard Area Applicable Technologies

FMCL Exceedance Area	Associated RCRA Unit	Description	Maximum COC Exceedance Factor									Applicable Remedial Technologies										
			Organics			Inorganics				TPH		Soil and Groundwater					Groundwater					
			cVOCs (TCE, cDCE, VC)	PCBs	cPAH	Arsenic	Copper and Zinc	Cadmium	Cyanide	Benzene, Ethylbenzene, GRPH	DRPH, MoRPH, Naphthalene	Corrective Action Not Required	Engineering Controls (Site Access, Surface Water Controls, and Paving)	Institutional Controls (Land Use Restrictions)	Long-term Groundwater Monitoring	Excavation with Off-Site Disposal	Short-term Groundwater Monitoring	Enhanced Reductive Dechlorination (ERD)	Enhanced Aerobic Degradation (EAD)	Air Sparging/SVE	Adaptive Management for Inorganics	Adaptive Management for Organics
RA 5 – South Yard (Soil - Direct Contact)																						
Soil Sample Location (PL2-112A, SS-09102, SS-09104, SS-09105, SS-09112, SB291-3, 288-6)	SWMU 2-91.70 Deactivated Waste Oil and Coolant Hold Area SWMU 2-89.68 Reclamation Yard			21							3.3	X	X	X	X	X						
RA 5 – South Yard (Groundwater)																						
cVOC-1	SWMU 2-104.71 Central Waste Storage Area	A-Level TCE and VC	172										X	X	X	X		X		X		X
cVOC-2		B-Level VC	67										X	X	X			X		X		X
BTEX-1		A-Level Benzene								3.6			X	X	X				X	X		X
BTEX-2	SWMU 2-91.70 Deactivated Waste Oil and Coolant Hold Area	A-Level Benzene								3.3			X	X	X	X			X	X		X
Arsenic-1	SWMU 2-104.71 Central Waste Storage Area	A-Level Arsenic				12							X	X	X						X	
Arsenic-14		C-Level Arsenic				2.0						X	X	X								
CuZn-1		B-Level Zinc					13						X	X	X		X				X	
DRPH-1		A-Level Diesel									1.3		X	X	X				X			X
DRPH-2	SWMU 2-91.70 Deactivated Waste Oil and Coolant Hold Area	A-Level Diesel and Motor Oil									18		X	X	X				X			X

Abbreviations:
BTEX - Benzene, Toluene, Ethylbenzene & Xylenes
cDCE - cis-1,2-Dichloroethene
COC - Constituent of Concern
cPAH - Carcinogenic Polycyclic Aromatic
CuZn - Copper and Zinc
cVOC - Chlorinated Volatile Organic Compound
DRPH - Diesel Range Petroleum Hydrocarbons
FMCL - Final Media Cleanup Level
GRPH - Gasoline Range Petroleum Hydrocarbons
MoRPH - Motor Oil Range Petroleum Hydrocarbons
PCBs - Polychlorinated Biphenyls
RCRA - Resource Conservation and Recovery Act
SVE - Soil Vapor Extraction
SWMU - Solid Waste Management Unit
TPH - Total Petroleum Hydrocarbon
TCE - Trichloroethene
VC - Vinyl Chloride

Notes:
1. The soil leaching pathway evaluates soil concentrations in the 6 to 11 ft bgs depth range with groundwater concentrations.
2. Maximum COC Exceedance Factor (unit less) = Maximum COC Concentration / FMCL value
3. Empty cells in the Maximum COC Exceedance Factor indicate constituents that are not COCs in the RA.

Table 6-5B: RA 5 - South Yard Area Alternatives

Alternatives			Alternatives for Organics																											Alternatives for Inorganics In Groundwater	Alternatives for Organics In Groundwater
			1			2					2a						2b						2c								
			Corrective Action Not Required with Controls			Enhanced Reductive Dechlorination (ERD)					ERD and Excavation with Off-Site Disposal						ERD followed by EAD						ERD, Excavation with Off-Site Disposal, followed by EAD							AM-1	AM-2
Technologies			Corrective Action Not Required	Engineering Controls	Institutional Controls	Engineering Controls	Institutional Controls	Long-Term Groundwater Monitoring	Short-Term Groundwater Monitoring	Enhanced Reductive Dechlorination (ERD)	Engineering Controls	Institutional Controls	Long-Term Groundwater Monitoring	Short-Term Groundwater Monitoring	Enhanced Reductive Dechlorination (ERD)	Excavation to Direct Contact	Engineering Controls	Institutional Controls	Long-Term Groundwater Monitoring	Short-Term Groundwater Monitoring	Enhanced Reductive Dechlorination (ERD)	Enhanced Aerobic Degradation (EAD)	Engineering Controls	Institutional Controls	Long-Term Groundwater Monitoring	Short-Term Groundwater Monitoring	Enhanced Reductive Dechlorination (ERD)	Enhanced Aerobic Degradation (EAD)	Excavation to Direct Contact	Adaptive Management	Adaptive Management
FMCL Exceedance Area	**Associated RCRA Unit**	**Description**																													
RA 5 – South Yard (Soil > FMCLs)																															
Soil Sample Locations (PL2-112A, SS-09102, SS-09104, SS-09105, SS-09112, SB291-3, 288-6)	SWMU 2-91.70 Deactivated Waste Oil and Coolant Hold Area SWMU 2-89.68 Reclamation Yard		X	X	X	X	X	X			X	X	X			X	X	X	X				X	X	X				X		
RA 5 – South Yard (Groundwater > FMCLs)																															
cVOC-1	SWMU 2-104.71 Central Waste Storage Area	A-Level TCE and VC		X	X	X	X	X		X	X	X	X		X	X	X	X	X		X		X	X	X		X		X		X
cVOC-2		B-Level VC		X	X	X	X	X		X	X	X	X		X		X	X	X		X		X	X	X		X				X
BTEX-1		A-Level Benzene		X	X	X	X	X			X	X	X				X	X	X			X	X	X	X			X			X
BTEX-2	SWMU 2-91.70 Deactivated Waste Oil and Coolant Hold Area	A-Level Benzene		X	X	X	X	X			X	X	X			X	X	X	X			X	X	X	X			X	X		X
Arsenic-1	SWMU 2-104.71 Central Waste Storage Area	A-Level Arsenic		X	X	X	X	X			X	X	X				X	X	X				X	X	X					X	
Arsenic-14		C-Level Arsenic	X	X	X	X	X				X	X					X	X					X	X							
CuZn-1		B-Level Zinc		X	X	X	X	X	X		X	X	X	X			X	X	X	X			X	X	X	X				X	
DRPH-1		A-Level Diesel		X	X	X	X	X			X	X	X				X	X	X			X	X	X	X			X			X
DRPH-2	SWMU 2-91.70 Deactivated Waste Oil and Coolant Hold Area	A-Level Diesel and Motor Oil		X	X	X	X	X			X	X	X				X	X	X			X	X	X	X			X			X

Abbreviations:

BTEX - Benzene, toluene, ethylbenzene, xylene
CuZn - Copper and Zinc
cVOC - Chlorinated Volatile Organic Compound
DRPH - Diesel Range Petroleum Hydrocarbons
FMCL - Final Media Cleanup Level
RCRA - Resource Conservation and Recovery Act
SWMU - Solid Waste Management Unit
TCE - Trichloroethene
VC - Vinyl Chloride

Table 6-5C: RA 5 - South Yard Area Evaluation of Alternatives

RCRA Alternative Evaluation Standards	Alternatives for Organics					Alternatives for Inorganics and Organics in Groundwater
	1	2	2a	2b	2c	AM-1 or AM-2
	Corrective Action Not Required (with Controls)	Enhanced Reductive Dechlorination	Enhanced Reductive Dechlorination with Excavation	Enhanced Reductive Dechlorination with Enhanced Aerobic Degradation	Enhanced Reductive Dechlorination, Enhanced Aerobic Degradation with Excavation	Adaptive Management
Determining Whether Alternative Complies with the Standards	**Ratings are Low = 1, Medium Low = 2, Medium = 3 Medium High = 4 and High = 5**					
Protect Human Health and the Environment	Yes	Yes	Yes	Yes	Yes	Yes
Attain FMCLs	Yes	Yes	Yes	Yes	Yes	Yes
Control Source of the Releases	Yes	Yes	Yes	Yes	Yes	Yes
Comply with Applicable Standards (With or Without Waivers)	Yes	Yes	Yes	Yes	Yes	Yes
Other Factors						
Long-term Reliability and Effectiveness	2	3	5	5	5	TBD
Reduction in Toxicity, Mobility, or Volume of Waste	2	4	4	5	5	TBD
Short-term Effectiveness	5	5	4	4	3	TBD
Implementability	5	4	4	3	3	TBD
Cost Effectiveness	5	4	3	3	2	TBD
Restoration Timeframe	2	4	5	4	5	TBD
Total Net Benefit	21	24	25	24	23	NA
Recommended Alternative - 2a Enhanced Reductive Dechlorination with Excavation						

Notes:
Yes - Indicates that the alternative at a minimum meets the RCRA standard.
TBD - To be determined (if needed), actual technology is dependent on site conditions and constituent(s) following implementation of recommended alternative.

Table 6-6A: RA 6 - OA 18 Area Applicable Technologies

FMCL Exceedance Area	Associated RCRA Unit	Description	Maximum COC Exceedance Factor									Applicable Remedial Technologies								
			Organics			Inorganics				TPH		Soil and Groundwater					Groundwater			
			cVOCs (TCE, cDCE, VC)	PCBs	cPAH	Arsenic	Copper and Zinc	Cadmium	Cyanide	Benzene, Ethylbenzene, GRPH	DRPH, MoRPH, Naphthalene	Corrective Action Not Required	Engineering Controls (Site Access, Surface Water Controls, and Paving)	Institutional Controls (Land Use Restrictions)	Long-term Groundwater Monitoring	Excavation with Off-Site Disposal	Short-term Groundwater Monitoring	Enhanced Reductive Dechlorination (ERD)	Adaptive Management for Inorganics	Adaptive Management for Organics
RA 6 - OA 18 Area (Soil - Direct Contact)																				
Soil Sample Location (SB-04023, SB-04025, SB-04026, SB-04028, 2-40-DP-071 2-40-DP-073, 2-40-DP-097, SB-04011, SB-04014, SB-04017, PL2-440A, PL2-440B)	OA 18 Building 2-40 East Parking Lot Area				129				383		3.1	X	X	X	X	X				
RA 6 - OA 18 Area (Groundwater)																				
cVOC-7	EMF Plume	B-Level TCE, cDCE, and VC	2.4K										X	X	X[a]			X[a]		X
CuZn-22	OA 18 Building 2-40 East Parking Lot Area	A-Level Copper					5.4					X	X	X	X[b]				X	
Cyanide-3		A-Level Cyanide							248			X	X	X					X	
Cadmium-5	OA 18 Building 2-40 East Parking Lot Area	A-Level Cadmium						19				X	X	X	X[b]				X	

Abbreviations:

cDCE - cis-1,2-Dichloroethene
COC - Constituent of Concern
cPAH - Carcinogenic Polycyclic Aromatic Hydrocarbons
CuZn - Copper and Zinc
cVOC - Chlorinated Volatile Organic Compound
DRPH - Diesel Range Petroleum Hydrocarbons
EMF - Electrical Manufacturing Facility
FMCL - Final Media Cleanup Level
GRPH - Gasoline Range Petroleum Hydrocarbons
MoRPH - Motor Oil Range Petroleum Hydrocarbons
OA - Other Area
PCBs - Polychlorinated Biphenyls
RCRA - Resource Conservation and Recovery Act
TPH - Total Petroleum Hydrocarbon
TCE - Trichloroethene
VC - Vinyl Chloride

Notes:

1. The soil leaching pathway evaluates soil concentrations in the 6 to 11 ft bgs depth range with groundwater concentrations.
2. Maximum COC Exceedance Factor (unit less) = Maximum COC Concentration / FMCL value
3. Empty cells in the Maximum COC Exceedance Factor indicate constituents that are not COCs in the RA.

[a] EMF Plume remediation and performance monitoring is ongoing under another USEPA supervised program.

[b] Long-term monitoring performed at Upgradient Monitoring Well location PL2-440A.

Table 6-6B: RA 6 - OA 18 Area Alternatives

Alternatives			Alternatives for Organics							Alternatives for Inorganics In Groundwater	Alternatives for Organics In Groundwater
			1			2					
Technologies			Corrective Action Not Required with Controls			Excavation with Off-Site Disposal				AM-1	AM-2
FMCL Exceedance Area	Associated RCRA Unit	Description	Corrective Action Not Required	Engineering Controls	Institutional Controls	Engineering Controls	Institutional Controls	Long-term Groundwater Monitoring	Excavation to Direct Contact	Adaptive Management	Adaptive Management
FMCL Exceedance Area	Associated RCRA Unit	Description									
RA 6 - OA 18 Area (Soil > FMCLs)											
Soil Sample Location (SB-04023, SB-04025, SB-04026, SB-04028, 2-40-DP-071 2-40-DP-073, 2-40-DP-097, SB-04011, SB-04014, SB-04017, PL2-440A, PL2-440B)	OA 18 Building 2-40 East Parking Lot Area		X	X	X	X	X	X	X		
RA 6 - OA 18 Area (Groundwater >FMCLs)											
cVOC-7	EMF Plume	B-Level TCE, cDCE, and VC		X	X	X	X	X[a]			X
CuZn-22	OA 18 Building 2-40 East Parking Lot Area	A-Level Copper	X	X	X	X	X			X	
Cyanide-3		A-Level Cyanide	X	X	X	X	X		X	X	
Cadmium-5		A-Level Cadmium	X	X	X	X	X		X	X	

Abbreviations:

CuZn - Copper and Zinc
cVOC - Chlorinated Volatile Organic Compound
EMF - Electrical Manufacturing Facility
FMCL - Final Media Cleanup Level
OA - Other Area
RCRA - Resource Conservation and Recovery Act

Notes:

[a] EMF Plume remediation and performance monitoring is ongoing under another EPA supervised program.

Table 6-6C: RA 6 - OA-18 Area Evaluation of Alternatives

RCRA Alternative Evaluation Standards	Alternatives		Alternatives for Inorganics and Organics in Groundwater
	1	2	AM-1 or AM-2
	Corrective Action Not Required (with Controls)	Excavation	Adaptive Management
Determining Whether Alternative Complies with the Standards	**Ratings are Low = 1, Medium Low = 2, Medium = 3 Medium High = 4 and High = 5**		
Protect Human Health and the Environment	Yes	Yes	Yes
Attain FMCLs	Yes	Yes	Yes
Control Source of the Releases	Yes	Yes	Yes
Comply with Applicable Standards (With or Without Waivers)	Yes	Yes	Yes
Other Factors			
Long-term Reliability and Effectiveness	2	5	TBD
Reduction in Toxicity, Mobility, or Volume of Waste	2	3	TBD
Short-term Effectiveness	5	3	TBD
Implementability	5	4	TBD
Cost Effectiveness	5	3	TBD
Restoration Timeframe	2	5	TBD
Total Net Benefit	21	23	NA
Recommended Alternative - 2 Excavation to FMCLs (with Long-term Monitoring)			

Notes:
Yes - Indicates that the alternative at a minimum meets the RCRA standard.
TBD - To be determined (if needed), actual technology is dependent on site conditions and constituent(s) following implementation of recommended alternative.

Table 6-7A: RA 7 - Unpaved Shoreline Area Applicable Technologies

FMCL Exceedance Area	Associated RCRA Unit	Description	Maximum COC Exceedance Factor									Applicable Remedial Technologies								
			Organics			Inorganics				TPH		Soil and Groundwater						Groundwater*		
			cVOCs (TCE, cDCE, VC)	PCBs	cPAH	Arsenic	Copper and Zinc	Cadmium	Cyanide	Benzene, Ethylbenzene, GRPH	DRPH, MoRPH, Naphthalene	Corrective Action Not Required	Engineering Controls (Site Access, Surface Water Controls, and Paving)	Institutional Controls (Land Use Restrictions)	Long-term Groundwater Monitoring	Bioventing	Excavation with Off-Site Disposal	Short-term Groundwater Monitoring	Adaptive Management for Inorganics	Adaptive Management for Organics
RA 7 - Unpaved Shoreline Area (Soil - Direct Contact)																				
Soil Sample Location (P2IM-SM-05)	SWMU 2-41.31 Machine Pits	North Stormwater Swale	2.6							1.5	30	X	X	X	X	X	X			
RA 7 - Unpaved Shoreline Area (Groundwater)																				
cVOC-8	None	A-Level TCE and VC	7.7										X	X	X					X
cVOC-9		C-Level cDCE and VC	10									X	X	X						
cVOC-10		A-Level TCE, cDCE, and VC	72										X	X	X					X
Arsenic-3	None	A-Level Arsenic				3.3							X	X	X				X	
CuZn-8	None	B-Level Zinc					3.4					X	X	X						
CuZn-9		C-Level Zinc					2.9					X	X	X						
CuZn-18							2.7					X	X	X						
CuZn-19		B-Level Zinc					2.1					X	X	X						
Cyanide-4	OA-2 Building 2-66 Soil	B-Level Cyanide							6				X	X	X			X	X	
Cyanide-5		A-Level Cyanide							5				X	X	X			X	X	
Cyanide-6	None	B-Level Cyanide							8				X	X	X			X	X	
DRPH-6	None	A-Level MoRPH									6.8		X	X	X	X	X			X

Abbreviations:

cDCE - cis-1,2-Dichloroethene
COC - Constituent of Concern
cPAH - Carcinogenic Polycyclic Aromatic Hydrocarbons
CuZn - Copper and Zinc
cVOC - Chlorinated Volatile Organic Compound
DRPH - Diesel Range Petroleum Hydrocarbons
FMCL - Final Media Cleanup Level
GRPH - Gasoline Range Petroleum Hydrocarbons
MoRPH - Motor Oil Range Petroleum Hydrocarbons
OA - Other Area
PCBs - Polychlorinated Biphenyls
RCRA - Resource Conservation and Recovery Act
SWMU - Solid Waste Management Unit
TCE - Trichloroethene
TPH - Total Petroleum Hydrocarbon
VC - Vinyl Chloride

Notes:

1. The soil leaching pathway evaluates soil concentrations in the 6 to 11 ft bgs depth range with groundwater concentrations.

2. Maximum COC Exceedance Factor (unit less) = Maximum COC Concentration / FMCL value

3. GRPH Maximum COC Exceedance Factor is calculated based on Residential Direct Contact TMCL (30 mg/kg) which is consistent with Section 2, Table 2.5.

4. Empty cells in the Maximum COC Exceedance Factor indicate constituents that are not COCs in the RA.

* Adaptive Management for PCBs may be implemented in the future if required as outlined in Section 6.12.

Table 6-7B: RA 7 - Unpaved Shoreline Area Alternatives

Alternatives*			Alternatives for Organics													Alternatives for Inorganics In Groundwater	Alternatives for Organics In Groundwater
			1			2					3					AM-1	AM-2
			Corrective Action Not Required with Controls			Bioventing					Excavation with Off-Site Disposal and Long-term Monitoring						
Technologies			Corrective Action Not Required	Engineering Controls	Institutional Controls	Engineering Controls	Institutional Controls	Long-term Groundwater Monitoring	Short-term Groundwater Monitoring	Bioventing	Engineering Controls	Institutional Controls	Long-term Groundwater Monitoring	Short-term Groundwater Monitoring	Excavation to Direct Contact	Adaptive Management	Adaptive Management
FMCL Exceedance Area	**Associated RCRA Unit**	**Description**															
RA 7 - Unpaved Shoreline Area (Soil > FMCLs)																	
Soil Sample Location (P2IM-SM-05)	SWMU 2-41.31 Machine Pits	North Stormwater Swale	X	X	X	X	X	X		X	X	X	X		X		
RA 7 - Unpaved Shoreline Area (Groundwater > FMCLs)																	
cVOC-8	None	A-Level TCE and VC		X	X	X	X				X	X	X				X
cVOC-9		C-Level cDCE and VC	X	X	X	X	X	X			X	X					
cVOC-10		A-Level TCE and VC		X	X	X	X				X	X	X				X
Arsenic-3	None	A-Level Arsenic		X	X	X	X	X			X	X	X			X	
CuZn-8	None	B-Level Zinc	X	X	X												
CuZn-9		C-Level Zinc	X	X	X												
CuZn-18			X	X	X												
CuZn-19		B-Level Zinc	X	X	X												
Cyanide-4	OA-2 Building 2-66 Soil	B-Level Cyanide		X	X	X	X		X		X	X		X		X	
Cyanide-5		A-Level Cyanide		X	X	X	X		X		X	X		X		X	
Cyanide-6	None	B-Level Cyanide		X	X	X	X		X		X	X		X		X	
DRPH-6	None	A-Level MoRPH		X	X	X	X	X		X	X	X	X		X		X

Abbreviations:

CuZn - Copper and Zinc
cVOC - Chlorinated Volatile Organic Compound
DRPH - Diesel Range Petroleum Hydrocarbons
FMCL - Final Media Cleanup Level
RCRA - Resource Conservation and Recovery Act
PCBs - Polychlorinated Biphenyls

Notes:

* Alternative AM-3 Adaptive Management for PCBs may be implemented in the future if required as outlined in Section 6.12.

Table 6-7C: RA 7 - Unpaved Shoreline Area Evaluation of Alternatives

RCRA Alternative Evaluation Standards	Alternatives for Organics in Soil			Alternatives for Organics, Inorganics, and PCBs in Groundwater
	1	2	3	AM-1, AM-2, or AM-3
	Corrective Action Not Required (with Controls)	Bioventing	Excavation	Adaptive Management
Determining Whether Alternative Complies with the Standards	**Ratings are Low = 1, Medium Low = 2, Medium = 3 Medium High = 4 and High = 5**			
Protect Human Health and the Environment	Yes	Yes	Yes	Yes
Attain FMCLs	Yes	Yes	Yes	Yes
Control Source of the Releases	Yes	Yes	Yes	Yes
Comply with Applicable Standards (With or Without Waivers)	Yes	Yes	Yes	Yes
Other Factors				
Long-term Reliability and Effectiveness	2	4	5	TBD
Reduction in Toxicity, Mobility, or Volume of Waste	2	4	2	TBD
Short-term Effectiveness	5	4	3	TBD
Implementability	5	4	2	TBD
Cost Effectiveness	5	4	2	TBD
Restoration Timeframe	2	4	4	TBD
Total Net Benefit	21	24	18	NA
Recommended Alternative - 2 Bioventing (with Long-term Monitoring)				

Notes:
Yes - Indicates that the alternative at a minimum meets the RCRA standard.
TBD - To be determined (if needed), actual technology is dependent on site conditions and constituent(s) following implementation of recommended alternative.

Table 6-8A: RA 8 - Paved Industrial Area Applicable Technologies

FMCL Exceedance Area	Associated RCRA Unit	Description	Maximum COC Exceedance Factor										Applicable Remedial Technologies								
			Organics			Inorganics					TPH		Soil and Groundwater					Groundwater*			
			cVOCs (TCE, cDCE, VC)	PCBs	cPAH	Arsenic	Copper and Zinc	Chromium	Cadmium	Cyanide	Benzene, Ethylbenzene, GRPH	DRPH, MoRPH, Naphthalene	Corrective Action Not Required	Engineering Controls (Site Access, Surface Water Control, and Paving)	Institutional Controls (Land Use Restrictions)	Long-term Groundwater Monitoring	Excavation with Off-Site Disposal	Short-term Groundwater Monitoring	Enhanced Reductive Dechlorination (ERD)	Adaptive Management for Inorganics	Adaptive Management for Organics
RA 8 - Paved Industrial Area (Soil - Direct Contact)																					
Soil Sample Location (P2-SM-123)	OA 21 Building 2-44 Machine Shop Area											3.5	X	X	X	X	X				
Soil Sample Location (P2IM-SM-186)	SWMU 2-41.31 Machine Pits											5.6	X	X	X	X	X				
Soil Sample Location (PL2-2-10-JF02)	OA 6 Northeast Area											2.4	X	X	X	X	X				
Soil Sample Location (PL2-201B)						3.3							X	X	X	X	X				
Soil Sample Location (B-24)	None	UST PL-4			1.3								X	X	X	X	X				
Soil Sample Location (SB-01023)	SWMU 2-10.7 – Paint Strip/Tank Line							2.9					X	X	X	X	X				
Soil Sample Location (BO7)	SWMU 2-10.8 Anodic and Alodine Tank Lines									1.8			X	X	X	X	X				
Soil Sample Location (CO2)	OA 8 (SWMU 2-09.2) Building 2-09 Chrome Waste Tank									1.6			X	X	X	X	X				
RA 8 - Paved Industrial Area (Groundwater)																					
cVOC-3	OA-12 Building 2-60s Area	A-Level TCE and VC	41											X	X	X			X		X
cVOC-7	EMF Plume	B-Level cDCE and VC	2.4K											X	X	X[a]			X[a]		X
cVOC-8	None	A-Level TCE and VC	8											X	X	X			X		X
cVOC-12			17											X	X	X			X		X
cVOC-13		A-Level TCE	11.8											X	X	X			X		X
BTEX-6	None	A-Level Benzene									5.8		X	X	X	X					
BTEX-7		A-Level Benzene and Ethylbenzene									21		X	X	X	X	X				

Table 6-8A: RA 8 - Paved Industrial Area Applicable Technologies

FMCL Exceedance Area	Associated RCRA Unit	Description	Maximum COC Exceedance Factor										Applicable Remedial Technologies								
			Organics			Inorganics					TPH		Soil and Groundwater					Groundwater*			
			cVOCs (TCE, cDCE, VC)	PCBs	cPAH	Arsenic	Copper and Zinc	Chromium	Cadmium	Cyanide	Benzene, Ethylbenzene, GRPH	DRPH, MoRPH, Naphthalene	Corrective Action Not Required	Engineering Controls (Site Access, Surface Water Control, and Paving)	Institutional Controls (Land Use Restrictions)	Long-term Groundwater Monitoring	Excavation with Off-Site Disposal	Short-term Groundwater Monitoring	Enhanced Reductive Dechlorination (ERD)	Adaptive Management for Inorganics	Adaptive Management for Organics
BTEX-8	Next to 2-10 north sheetpile	B-Level Benzene									19			X	X	X					X
DRPH-7	None	A-Level Naphthalene										2.7	X	X	X						
Arsenic-3	OA-17.8 Transformer Vaults	A-Level Arsenic				3.3								X	X	X				X	
Arsenic-4	None					5.2								X	X	X				X	
Arsenic-7	SWMU 2-10.4 Zyglo Penetrant Spray Booth					1.3							X	X	X						
Arsenic-8	SWMU 2-10.9 Aluminum Chem Mill Area					2.2								X	X	X				X	
Arsenic-10	None					1.9							X	X	X						
Arsenic-11						138								X	X	X		X		X	
Arsenic-12						6.2								X	X	X				X	
Arsenic-13		C-Level Arsenic				16.9							X	X	X						
CuZn-3	None	A-Level Copper					5.3						X	X	X	X					
CuZn-11							2.6						X	X	X	X					
CuZn-12	AOC 2-31.21 TCE Degreaser	C-Level Copper					1.4						X	X	X						
CuZn-13	None	C-Level Zinc					1.25						X	X	X						
CuZn-17		A-Level Copper					1.9						X	X	X						
CuZn-20		B-Level Copper and Zinc					3.9						X	X	X	X					
CuZn-21		A-Level Copper					7.5						X	X	X	X					

Table 6-8A: RA 8 - Paved Industrial Area Applicable Technologies

FMCL Exceedance Area	Associated RCRA Unit	Description	Maximum COC Exceedance Factor										Applicable Remedial Technologies								
			Organics			Inorganics					TPH		Soil and Groundwater					Groundwater*			
			cVOCs (TCE, cDCE, VC)	PCBs	cPAH	Arsenic	Copper and Zinc	Chromium	Cadmium	Cyanide	Benzene, Ethylbenzene, GRPH	DRPH, MoRPH, Naphthalene	Corrective Action Not Required	Engineering Controls (Site Access, Surface Water Control, and Paving)	Institutional Controls (Land Use Restrictions)	Long-term Groundwater Monitoring	Excavation with Off-Site Disposal	Short-term Groundwater Monitoring	Enhanced Reductive Dechlorination (ERD)	Adaptive Management for Inorganics	Adaptive Management for Organics
CuZn-22	None	A-Level Copper and Zinc					44						X	X	X	X					
CuZn-23		C-Level Zinc					11.7						X	X	X						
Cyanide-1	None	A-Level Cyanide								64			X	X	X						
Cyanide-2										17			X	X	X						

Abbreviations:

AOC - Area of Concern
BTEX - Benzene, Toluene, Ethylbenzene & Xylenes
cDCE - cis-1,2-Dichloroethene
COC - Constituent of Concern
cPAH - Carcinogenic Polycyclic Aromatic Hydrocarbons
CuZn - Copper and Zinc
cVOC - Chlorinated Volatile Organic Compound
DRPH - Diesel Range Petroleum Hydrocarbons
EMF - Electrical Manufacturing Facility
FMCL - Final Media Cleanup Level
GRPH - Gasoline Range Petroleum Hydrocarbons
MoRPH - Motor Oil Range Petroleum Hydrocarbons
OA - Other Area
PCBs - Polychlorinated Biphenyls
RCRA - Resource Conservation and Recovery Act
SWMU - Solid Waste Management Unit
TCE - Trichloroethene
TPH - Total Petroleum Hydrocarbon
VC - Vinyl Chloride

Notes:

1. The soil leaching pathway evaluates soil concentrations in the 6 to 11 ft bgs depth range with groundwater concentrations.
2. Maximum COC Exceedance Factor (unit less) = Maximum COC Concentration / FMCL value
3. Empty cells in the Maximum COC Exceedance Factor indicate constituents that are not COCs in the RA.

[a] EMF Plume remediation and performance monitoring is ongoing under another USEPA supervised program.

* Adaptive Management for PCBs may be implemented in the future if required as outlined in Section 6.13.

Table 6-8B: RA 8 - Paved Industrial Area Alternatives

Alternatives*			Alternatives for Organics								Alternatives for Inorganics In Groundwater	Alternatives for Organics In Groundwater
			1			2						
			Corrective Action Not Required with Controls			Excavation with Off-Site Disposal					AM-1	AM-2
Technologies			Corrective Action Not Required	Engineering Controls	Institutional Controls	Engineering Controls	Institutional Controls	Long-term Groundwater Monitoring	Short-term Groundwater Monitoring	Excavation to Direct Contact	Adaptive Management	Adaptive Management
FMCL Exceedance Area	**Associated RCRA Unit**	**Description**										
RA 8 - Paved Industrial Area (Soil > FMCLs)												
Soil Sample Location (P2-SM-123)	OA 21 Building 2-44 Machine Shop Area	MoRPH	X	X	X	X	X	X		X		
Soil Sample Location (P2IM-SM-186)	SWMU 2-41.31 Machine Pits	MoRPH	X	X	X	X	X	X		X		
Soil Sample Location (PL2-2-10-JF02)	OA 6 Northeast Area	MoRPH	X	X	X	X	X	X		X		
Soil Sample Location (PL2-201B)	OA 6 Northeast Area	Arsenic	X	X	X	X	X	X		X		
Soil Sample Location (B-24)	None	UST PL-4, cPAHs	X	X	X	X	X	X		X		
Soil Sample Location (SB-01023)	SWMU 2-10.7 – Paint Strip/Tank Line	Chromium	X	X	X	X	X	X		X		
Soil Sample Location (BO7)	SWMU 2-10.8 Anodic and Alodine Tank Lines	Cyanide	X	X	X	X	X	X		X		
Soil Sample Location (CO2)	OA 8 (SWMU 2-09.2) Building 2-09 Chrome Waste Tank	Cyanide	X	X	X	X	X	X		X		
RA 8 - Paved Industrial Area (Groundwater > FMCLs)												
cVOC-3	OA-12 Building 2-63 Area	A-Level TCE and VC		X	X	X	X	X				X
cVOC-7	EMF Plume	B-Level cDCE and VC		X	X	X	X	X[a]				X

Table 6-8B: RA 8 - Paved Industrial Area Alternatives

Alternatives*			Alternatives for Organics								Alternatives for Inorganics In Groundwater	Alternatives for Organics In Groundwater
			1			2						
			Corrective Action Not Required with Controls			Excavation with Off-Site Disposal					AM-1	AM-2
Technologies			Corrective Action Not Required	Engineering Controls	Institutional Controls	Engineering Controls	Institutional Controls	Long-term Groundwater Monitoring	Short-term Groundwater Monitoring	Excavation to Direct Contact	Adaptive Management	Adaptive Management
cVOC-8	None	A-Level TCE and VC		X	X	X	X	X				X
cVOC-12				X	X	X	X	X				X
cVOC-13		A-Level TCE		X	X	X	X	X				X
BTEX-6	None	A-Level Benzene	X	X	X	X	X	X				
BTEX-7		A-Level Benzene and Ethylbenzene	X	X	X	X	X	X		X		
BTEX-8	Next to 2-10 North Sheetpile	B-Level Benzene		X	X	X	X					X
DRPH-7	None	A-Level Naphthalene	X	X	X	X	X					
Arsenic-3	OA-17.8 Transformer Vaults	A-Level Arsenic		X	X	X	X	X			X	
Arsenic-4	None			X	X	X	X	X			X	
Arsenic-7	SWMU 2-10.4 Zyglo Penetrant Spray Booth		X	X	X	X	X					
Arsenic-8	SWMU 2-10.9 Aluminum Chem Mill Area			X	X	X	X	X			X	
Arsenic-10	None		X	X	X	X	X					
Arsenic-11				X	X	X	X	X	X		X	
Arsenic-12				X	X	X	X	X			X	
Arsenic-13		C-Level Arsenic	X	X	X	X	X					
CuZn-3	None	A-Level Copper	X	X	X	X	X	X				
CuZn-11			X	X	X	X	X	X				
CuZn-12	AOC 2-31.21 TCE Degreaser	C-Level Copper	X	X	X	X	X					

Table 6-8B: RA 8 - Paved Industrial Area Alternatives

Alternatives*			Alternatives for Organics								Alternatives for Inorganics In Groundwater	Alternatives for Organics In Groundwater
			1			2						
			Corrective Action Not Required with Controls			Excavation with Off-Site Disposal					AM-1	AM-2
Technologies			Corrective Action Not Required	Engineering Controls	Institutional Controls	Engineering Controls	Institutional Controls	Long-term Groundwater Monitoring	Short-term Groundwater Monitoring	Excavation to Direct Contact	Adaptive Management	Adaptive Management
CuZn-13	None	C-Level Zinc	X	X	X	X	X					
CuZn-17		A-Level Copper	X	X	X	X	X	X				
CuZn-20		B-Level Copper and Zinc	X	X	X	X	X	X				
CuZn-21		A-Level Copper	X	X	X	X	X	X				
CuZn-22		A-Level Copper and Zinc	X	X	X	X	X	X				
CuZn-23		C-Level Zinc	X	X	X	X	X					
Cyanide-1	None	A-Level Cyanide	X	X	X	X	X					
Cyanide-2			X	X	X	X	X					

Abbreviations:

BTEX - Benzene, toluene, ethylbenzene, xylene
CuZn - Copper/Zinc
cPAH - Carcinogenic Polycyclic Aromatic
cVOC - Chlorinated Volatile Organic Compound
EMF - Electrical Manufacturing Facility
EPA - Environmental Protection Agency
FMCL - Final Media Cleanup Level
GRPH - Gasoline Range Petroleum Hydrocarbons
MoRPH - Motor Oil Range Petroleum Hydrocarbons
NAPH - Naphthalene
OA - Other Area
PCBs - Polychlorinated Biphenyls
RCRA - Resource Conservation and Recovery Act
SWMU - Solid Waste Management Unit
UST - Underground Storage Tank

Notes:

[a] EMF Plume remediation and performance monitoring is ongoing under another EPA supervised program.
[b] Corrective Action Completed for C-Level Exceedance Areas represented by Nickel-20
* Alternative AM-3 Adaptive Management for PCBs may be implemented in the future if required as outlined in Section 6.13.

Table 6-8C: RA 8 - Paved Industrial Area Evaluation of Alternatives

RCRA Alternative Evaluation Standards	Alternatives for Organics and Inorganics in Soil		Alternatives for Organics, Inorganics, and PCBs in Groundwater
	1	2	AM-1, AM-2, or AM-3
	Corrective Action Not Required (with Controls)	Excavation	Adaptive Management
Determining Whether Alternative Complies with the Standards	**Ratings are Low = 1, Medium Low = 2, Medium = 3 Medium High = 4 and**		
Protect Human Health and the Environment	Yes	Yes	Yes
Attain FMCLs	Yes	Yes	Yes
Control Source of the Releases	Yes	Yes	Yes
Comply with Applicable Standards (With or Without Waivers)	Yes	Yes	Yes
Other Factors			
Long-term Reliability and Effectiveness	2	5	TBD
Reduction in Toxicity, Mobility, or Volume of Waste	2	3	TBD
Short-term Effectiveness	5	4	TBD
Implementability	5	4	TBD
Cost Effectiveness	5	4	TBD
Restoration Timeframe	2	4	TBD
Total Net Benefit	21	24	NA
Recommended Alternative - 2 Excavation to FMCLs (with Short- and Long-term Monitoring)			

Notes:
Yes - Indicates that the alternative at a minimum meets the RCRA standard.
TBD - To be determined (if needed), actual technology is dependent on site conditions and constituent(s) following implementation of recommended alternative.

Table 6-9A: RA 9 - OA 11 Area Applicable Technologies

FMCL Exceedance Area	Associated RCRA Unit	Description	Maximum COC Exceedance Factor									Applicable Remedial Technologies							
			Organics			Inorganics				TPH		Soil and Groundwater				Groundwater			
			cVOCs (TCE, cDCE, VC)	PCBs	cPAH	Arsenic	Copper and Zinc	Cadmium	Cyanide	Benzene, Ethylbenzene, GRPH	DRPH, MoRPH, Naphthalene	Corrective Action Not Required	Engineering Controls (Site Access, Surface Water Control, and Paving)	Institutional Controls (Land Use Restrictions)	Long-term Groundwater Monitoring	Short-term Groundwater Monitoring	Adaptive Management for Inorganics	Adaptive Management for Organics	Adaptive Management for PCBs
RA 9 – OA 11 Area (Soil does not exceed Direct Contact FMCLs) **RA 9 - OA 11 Area (Groundwater)**																			
cVOC-5	OA-1 Building 2-66 Southwest and AOC 2-66.53 TCE Degreaser	A-Level TCE, cDCE, and VC	5K										X	X	X			X	
BTEX-3	OA-11 Building 2-72 Area	A-Level Benzene, Ethylbenzene, and GRPH								429			X	X	X			X	
Arsenic-1	None	A-Level Arsenic				12.5							X	X	X		X		
CuZn-2	OA-2 Building 2-66 Soil	A-Level Zinc					5.4						X	X	X		X		
DRPH-4	OA-11 Building 2-72 Area	A-Level DRPH and MoRPH									3		X	X	X			X	
PCB-1		A-Level PCB		8									X	X	X	X			X

Abbreviations:

BTEX - Benzene, Toluene, Ethylbenzene & Xylenes
cDCE - cis-1,2-Dichloroethene
COC - Constituent of Concern
cPAH - Carcinogenic Polycyclic Aromatic Hydrocarbons
CuZn - Copper and Zinc
cVOC - Chlorinated Volatile Organic Compound
DRPH - Diesel Range Petroleum Hydrocarbons
FMCL - Final Media Cleanup Level
GRPH - Gasoline Range Petroleum Hydrocarbons
MoRPH - Motor Oil Range Petroleum Hydrocarbons
OA - Other Area
PCBs - Polychlorinated Biphenyls
RCRA - Resource Conservation and Recovery Act
SVE - Soil Vapor Extraction
TCE - Trichloroethene
TPH - Total Petroleum Hydrocarbon
VC - Vinyl Chloride

Notes:

1. The soil leaching pathway evaluates soil concentrations in the 6 to 11 ft bgs depth range with groundwater concentrations.
2. Maximum COC Exceedance Factor (unit less) = Maximum COC Concentration / FMCL value
3. Empty cells in the Maximum COC Exceedance Factor indicate constituents that are not COCs in the RA.

Table 6-9B: RA 9 - OA 11 Building 2-72 Area

Alternatives			Alternatives						Alternatives for Inorganics In Groundwater	Alternatives for Organics In Groundwater	Alternatives for PCBs In Groundwater
			1						AM-1	AM-2	AM-3
			Corrective Action Not Required (with Controls and Monitoring)								
Technologies			Corrective Action Not Required	Engineering Controls	Institutional Controls	Long-term Groundwater Monitoring	Short-term Groundwater Monitoring	Institutional Controls	Adaptive Management	Adaptive Management	Adaptive Management
FMCL Exceedance Area	**Associated RCRA Unit**	**Description**									
RA 9 – OA 11 Building 2-72 Area (Groundwater > FMCLs)											
cVOC-5	OA-1 Building 2-66 Southwest and AOC 2-	A-Level TCE, cDCE, and VC		X	X	X		X		X	
BTEX-3	OA-11 Building 2-72 Area	A-Level Benzene, Ethylbenzene, and GRPH		X	X	X		X		X	
Arsenic-1	None	A-Level Arsenic		X	X	X		X	X		
CuZn-2	OA-2 Building 2-66 Soil	A-Level Copper		X	X	X		X	X		
DRPH-4	OA-1 Building 2-66 Southwest	A-Level DRPH and MoRPH		X	X	X		X		X	
PCB-1	OA-19 Outfall #12 and Building 2-49 Stretch Press Pit	A-Level PCBs		X	X	X	X	X			X

Abbreviations:

AOC - Area of Concern
BTEX - Benzene, toluene, ethylbenzene, xylene
cDCE - cis-1,2-Dichloroethene
CuZn - Copper and Zinc
cVOC - Chlorinated Volatile Organic Compound
DRPH - Diesel Range Petroleum Hydrocarbons
FMCL - Final Media Cleanup Level
FMCL - Final Media Cleanup Level
GRPH - Gasoline Range Petroleum Hydrocarbons
NAPH - Naphthalene
OA - Other Area
PCBs - Polychlorinated Biphenyls
RCRA - Resource Conservation and Recovery Act
SWMU - Solid Waste Management Unit
TCE - Trichloroethene
VC - Vinyl Chloride

Table 6-9C: RA 9 - OA 11 Area Evaluation of Alternatives

RCRA Alternative Evaluation Standards	Alternatives for Organics, Inorganics, and PCBs in Groundwater	
	1	AM-1, AM-2, or AM-3
	Corrective Action Not Required (with Controls and Monitoring)	Adaptive Management
Determining Whether Alternative Complies with the Standards	**Ratings are Low = 1, Medium Low = 2, Medium = 3 Medium**	
Protect Human Health and the Environment	Yes	Yes
Attain FMCLs	Yes	Yes
Control Source of the Releases	Yes	Yes
Comply with Applicable Standards (With or Without Waivers)	Yes	Yes
Other Factors		
Long-term Reliability and Effectiveness	2	TBD
Reduction in Toxicity, Mobility, or Volume of Waste	2	TBD
Short-term Effectiveness	5	TBD
Implementability	5	TBD
Cost Effectiveness	5	TBD
Restoration Timeframe	2	TBD
Total Net Benefit	21	NA
Recommended Alternative - 1 Corrective Action Not Required (with Controls and Monitoring)		

Notes:
Yes - Indicates that the alternative at a minimum meets the RCRA standard.
TBD - To be determined (if needed), actual technology is dependent on site conditions and constituent(s) following implementation of recommended alternative.

Table 7-1: Recommended Remedial Alternatives

Remediation Area	Recommended Alternative	Description
RA 1 - 2-10 North Sheetpile Area	Alternative 2 - ERD	• ERD • Institutional Controls • Engineering Controls • Long-term Groundwater Monitoring for VOCs • Short-term Groundwater Monitoring for inorganics and BEHP
RA 2 - 2-10 South Sheetpile Area	Alternative 2 - ERD	• ERD • Institutional Controls • Engineering Controls • Long-term Groundwater Monitoring for VOCs • Short-term Groundwater Monitoring for inorganics
RA 3 - 2-31 Area	Alternative 2 - ERD	• ERD • Institutional Controls • Engineering Controls • Long-term Groundwater Monitoring for VOCs • Short-term Groundwater Monitoring for inorganics, BEHP, and PCBs
RA 4 - 2-66 Sheetpile and Surrounding Area	Alternative 2 - ERD	• ERD • Institutional Controls • Engineering Controls • Long-term Groundwater Monitoring for VOCs and metals • Short-term Groundwater Monitoring for nickel and PCBs
RA 5 - South Yard Area	Alternative 2a - ERD and Excavation with Off-Site Disposal	• Excavation with Off-Site Disposal to meet MoRPH and PCB soil FMCLs and support removal of soil potentially contributing to groundwater exceedance areas • ERD • Institutional Controls • Engineering Controls • Long-term Groundwater Monitoring for cVOCs • Short-term Groundwater Monitoring for inorganics
RA 6 - OA 18 Area	Alternative 2 - Excavation with Off-Site Disposal	• Excavation with Off-Site Disposal for cPAH, naphthalene, cyanide, DRPH, and MoRPH to approximately 7 feet bgs • Institutional Controls • Engineering Controls • Long-term Groundwater Monitoring (not directly applicable to groundwater exceedance areas or to FMCL exceedances in soil for RA6; however, A- and B-Level shoreline monitoring wells would be used to monitor groundwater at the POC downgradient from RA 6)
RA 7 - Unpaved Shoreline Area	Alternative 2 - Bioventing	• Bioventing • Institutional Controls • Engineering Controls • Long-term Groundwater Monitoring for VOCs • Short-term Groundwater Monitoring for inorganics and BEHP
RA 8 - Paved Industrial Area	Alternative 2 - Excavation with Off-Site Disposal	• Excavation with Off-Site Disposal for arsenic, chromium, cyanide, cPAH, and MoRPH to approximately 11 feet bgs • Institutional Controls • Engineering Controls • Long-term Monitoring for VOCs (not directly applicable to groundwater exceedance areas or to FMCL exceedances in soil for RA 8; however, A- and B-Level shoreline monitoring wells would be used to monitor groundwater at the POC downgradient from RA 8) • Short-term Groundwater Monitoring for inorganics and PCBs
RA 9 - OA 11 Area	Alternative 1 - Corrective Action Not Required (with Controls and Monitoring)	• No Corrective Action needed for soil and groundwater • Institutional Controls • Engineering Controls • Long-term Monitoring for VOCs • Short-term Monitoring for inorganics and PCBs

Abbreviations:

BTEX - Benzene, Toluene, Ethylbenzene, Total Xylenes
cPAH - Carcinogenic Polycyclic Aromatic Hydrocarbons
cVOC - Chlorinated Volatile Organic Compound
DRPH - Diesel Range Petroleum Hydrocarbons
ERD - Enhanced Reductive Dechlorination
FMCL - Final Media Cleanup Level
MoRPH - Motor Oil Range Petroleum Hydrocarbons
PCBs - Polychlorinated Biphenyls
POC - Point of Compliance
VOCs - Volatile Organic Compounds

Figures

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LEGEND

Plant 2 Property Boundary

0 600 1,200

Scale in Feet

Map Projection:
Washington State Plane North, Feet
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FIGURE **1-1**

VICINITY MAP

VOLUME X: CORRECTIVE MEASURES STUDY REPORT

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

Golder Associates

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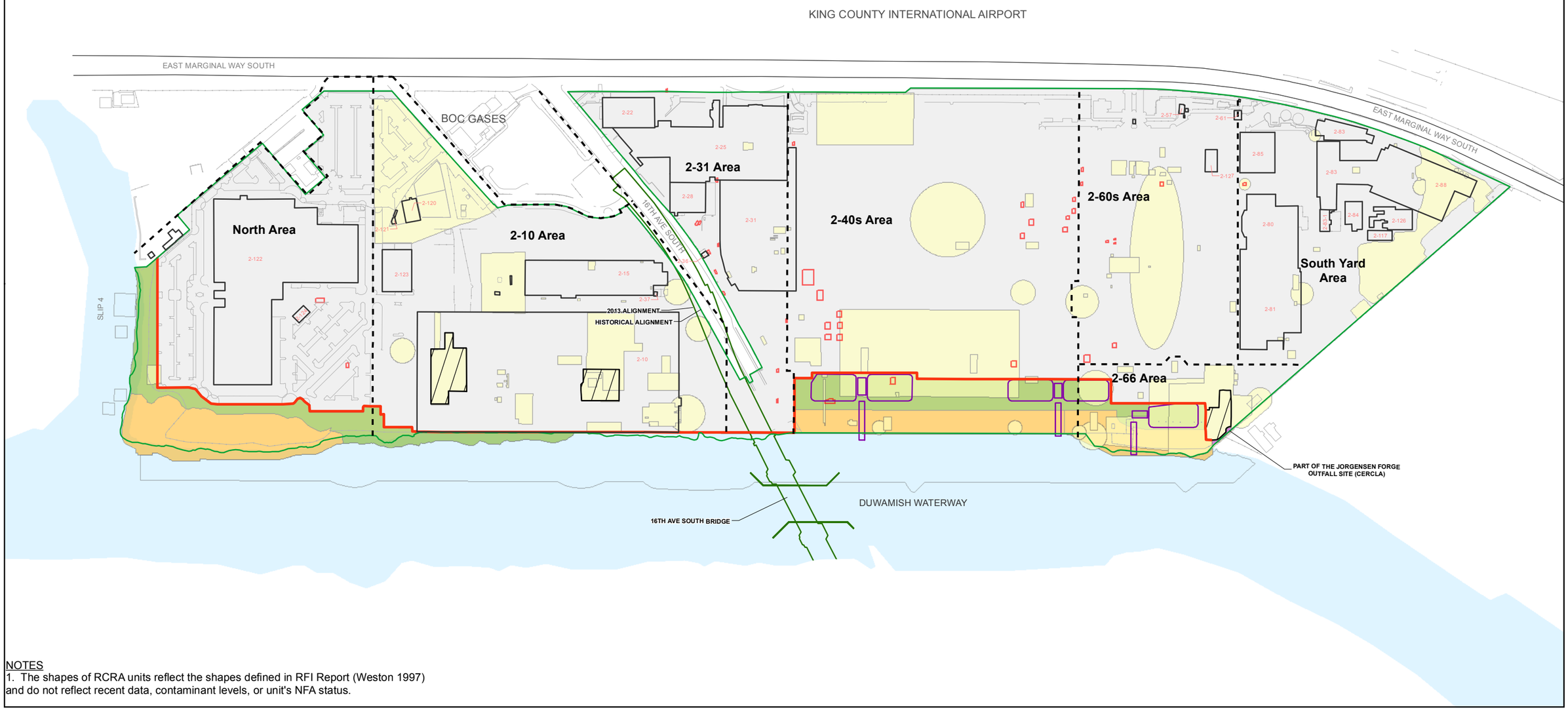

NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.

LEGEND

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- Removed Sump or UST
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area

- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
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FIGURE **1-2**

SITE PLAN WITH CMS STUDY AREAS

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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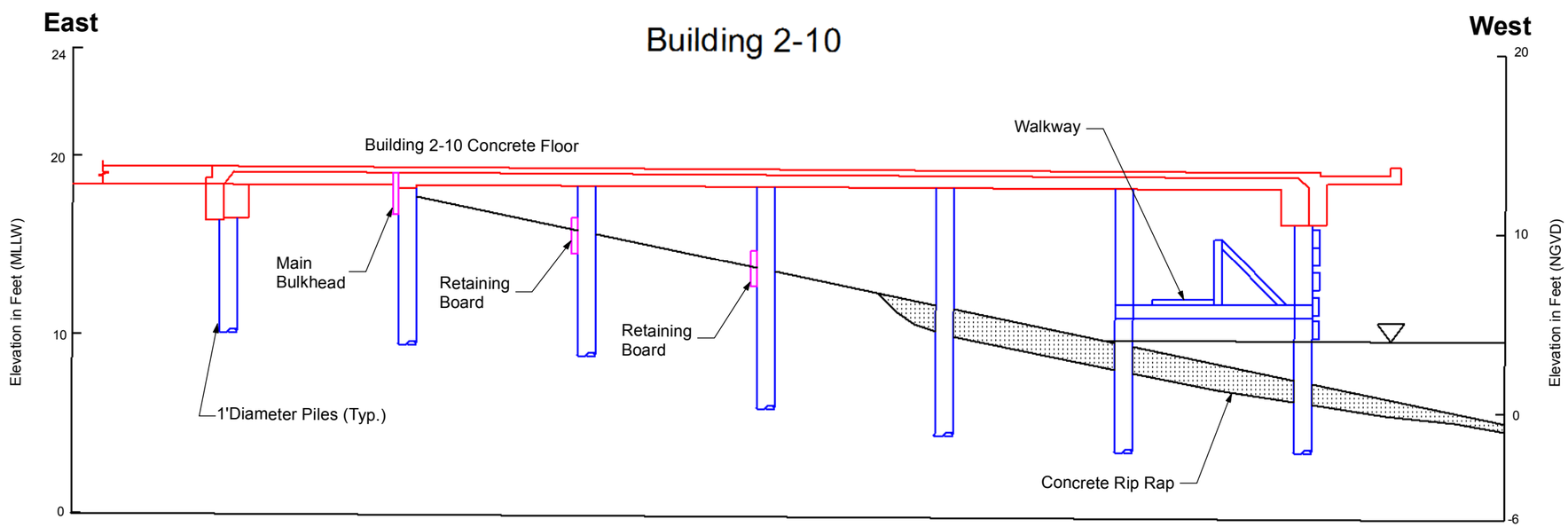

0 7.5
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983
Source:
Floyd|Snider (Cross Section),
Golder Associates Inc.

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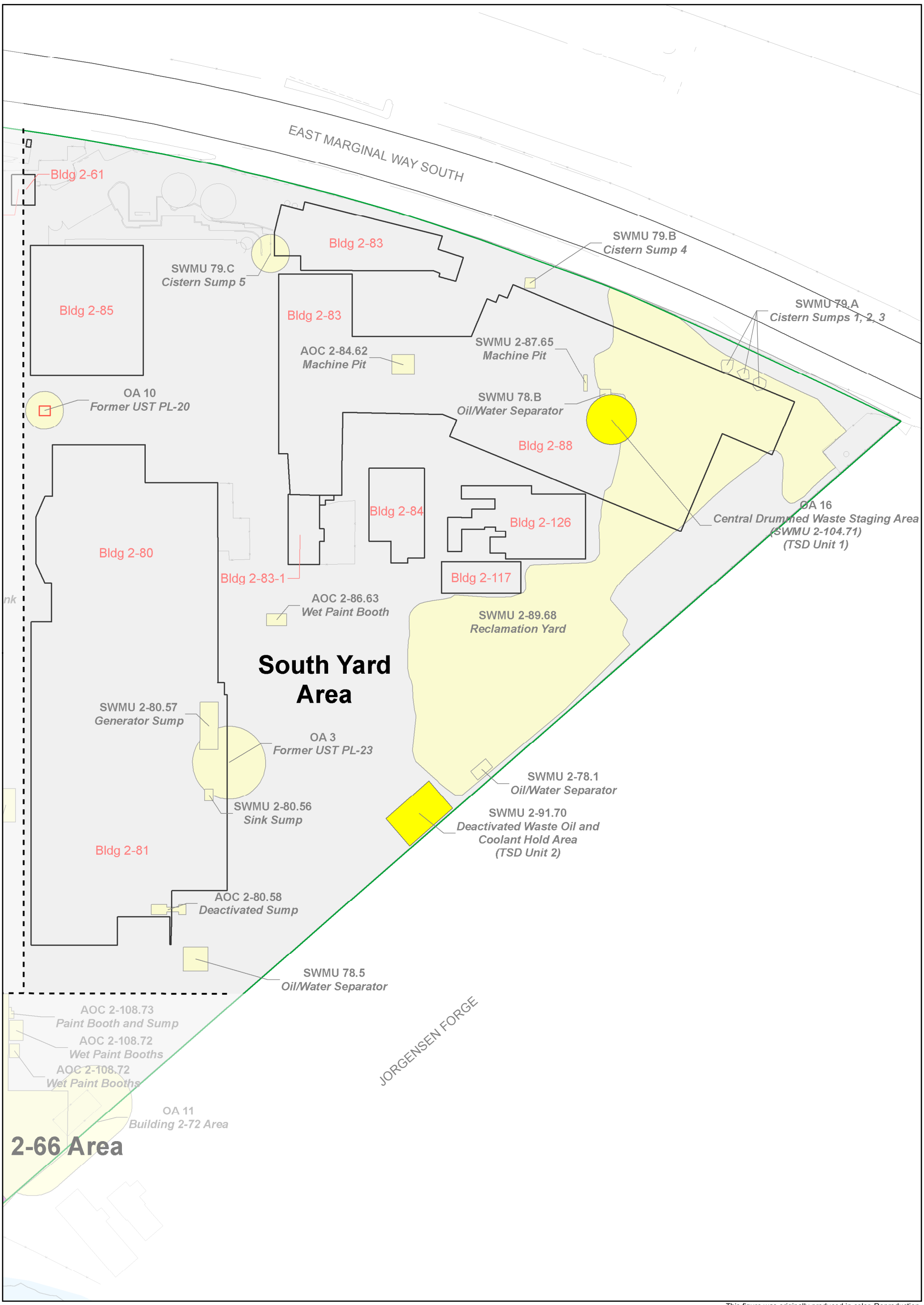
FIGURE **1-3**

2-10 BUILDING CROSS SECTION

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

Golder Associates



LEGEND

- Plant 2 Sub-Area Boundary
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- TSD - Treatment Storage and Disposal
- Removed Sump or UST
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area

- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 100
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

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FIGURE **1-4**

BOEING PLANT 2
SOUTH YARD AREA

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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EAST MARGINAL WAY SOUTH

Bldg 2-57
Bldg 2-61
Bldg 2-85
SWMU 79.C
Cistern Sump
AOC 2-62.45
Paint Booths
and Sumps
SWMU 2-62.43
Tank Line
Bldg 2-127
2-40s Area
UST PL-38
UST PL-37
AOC 2-62.46
Paint Booth and Sump
OA 10
Former UST PL-20
SWMU 77.A
PCB Retention Tank
UST PL-59
Sump SPL-044-009
Sump SPL-044-010
2-60s Area
015
Sump SPL-
044-011
Sump SPL-
044-030
Sumps SPL-063-006
to SPL-063-008
Bldg 2-80
SWMU 2-63.47
Dilute Chrome Tank
South Yard
Area
OA 17.6
Transformer Vault 6
SWMU 2-64.48
Underground
Waste Tank
OA 12
Building 2-63 Area
SWMU 78.C
Oil/Water
Separator
SWMU 77.B
PCB Retention Tank
SWMU 2-80.57
Generator Sump
OA 13
Building 2-44
Steam Drain
SWMU 2-64.49
Air Compressor
Building Sump and
Accumulation Area
SWMU 2-65.50
Machine Pit
SWMU 2-78.6
Oil/Water Separator
SWMU 2-70.55
East Steam Clean
Area and UST
OA 9
Former USTs
PL-16, 17, 18, including
SWMU 2-78.6
Bldg 2-81
Sump SPL-049-006
Sump SPL-049-009
OA 17.8
Transformer Vault 8
OA 17.13
Transformer
Vault 13
AOC 2-66.52
Machine Pit
AOC 2-108.73
Paint Booth and Sump
AOC 2-108.72
Wet Paint Booths
OA 14
Building 2-49
Machine Pits
AOC 2-66.53
TCE Degreaser
2-66 Area
OA 11
Building 2-72 Area
OA 22.A
Outfall No. 14 Area
OA 1
Building 2-66
Southwest
OA 2
Building
2-66 Soil
OA 19
Building 2-49 Stretch

LEGEND

- Plant 2 Sub-Area Boundary
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- Removed Sump or UST
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area

- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 100
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
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FIGURE **1-5**
BOEING PLANT 2
2-60s AREA
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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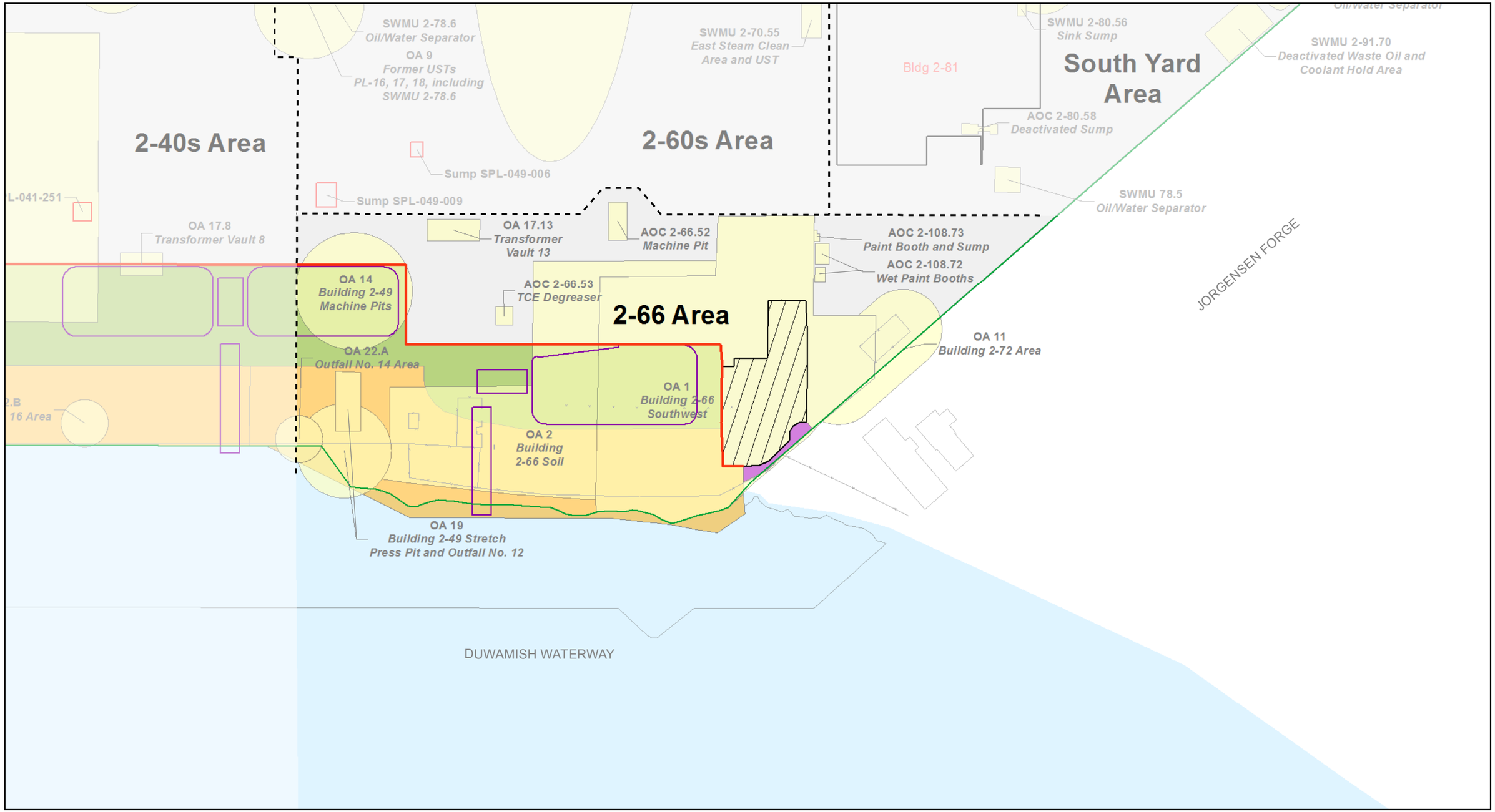
User: BVang-Johnson



LEGEND

- Plant 2 Sub-Area Boundary
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- Removed Sump or UST
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area

- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 100
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
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FIGURE **1-6**

BOEING PLANT 2

2-66 AREA

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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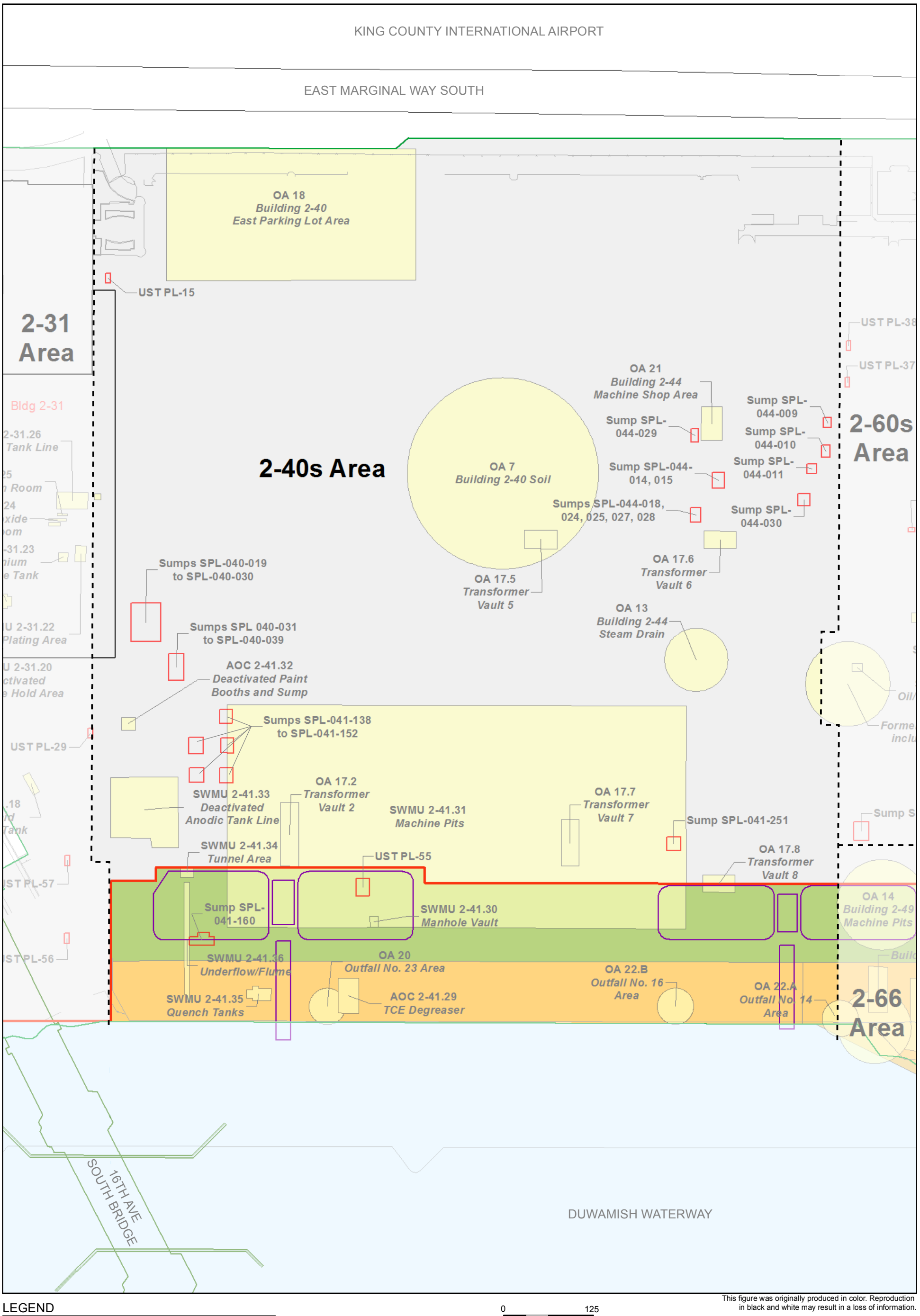

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LEGEND

- Plant 2 Sub-Area Boundary
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- Removed Sump or UST
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area

- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 125
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

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FIGURE **1-7**

BOEING PLANT 2

2-40s AREA

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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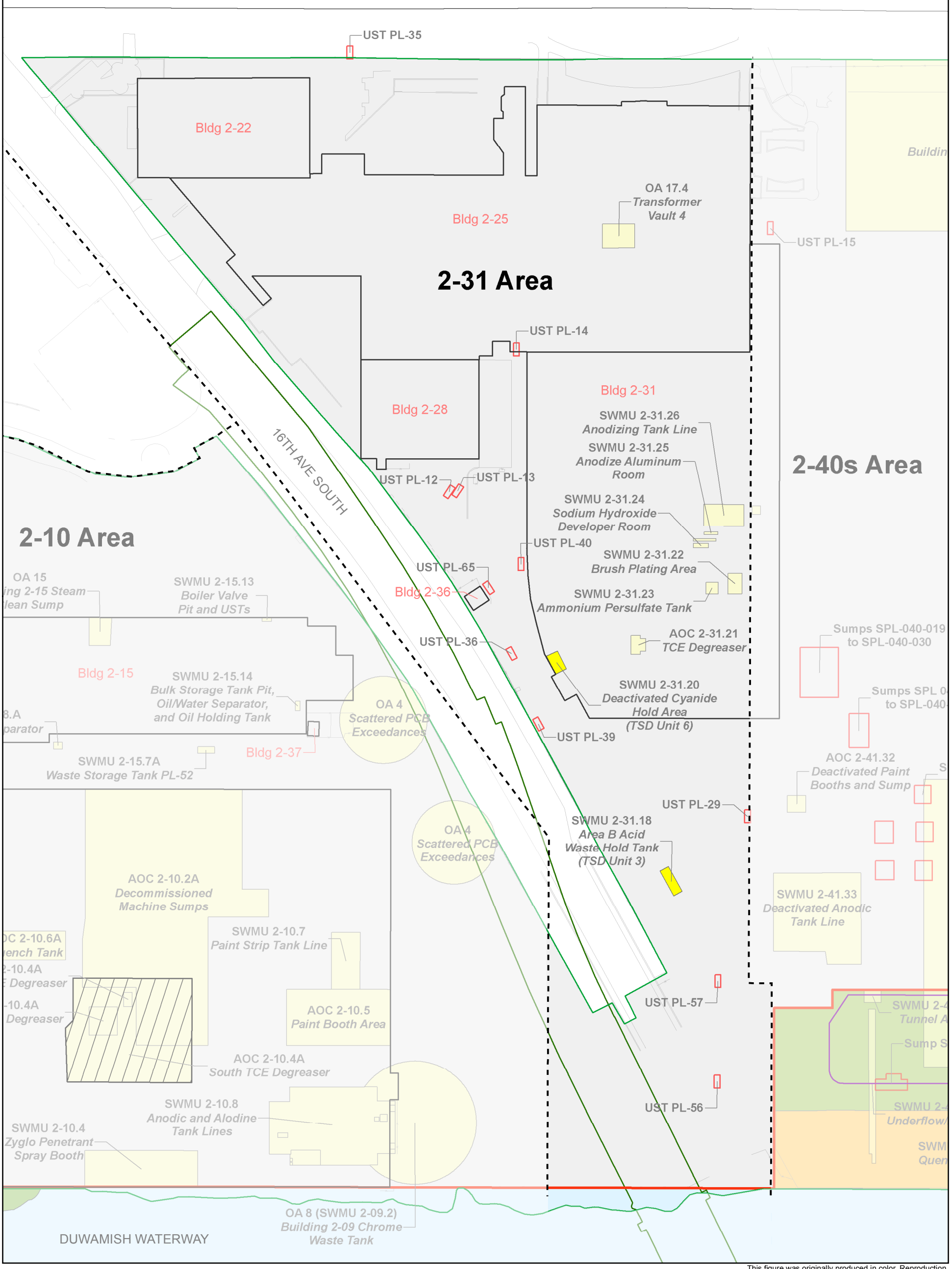

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LEGEND

- Plant 2 Sub-Area Boundary
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- TSD - Treatment Storage and Disposal
- Removed Sump or UST
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area

- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 100
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

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FIGURE **1-8**

BOEING PLANT 2

2-31 AREA

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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Date: 10/25/2017

User: HJackson

KING COUNTY INTERNATIONAL AIRPORT

EAST MARGINAL WAY SOUTH

BOC GASES

UST PL-35

Bldg 2-22

OA 17
Transformer

Bldg 2-25

2-31
Area

UST PL-14

Bldg 2-28

OA 6
Northeast Area

Bldg 2-120

Bldg 2-121

SWMU 78.7
Oil/Water Separators

2-10 Area

UST PL-13

UST PL-12

UST PL-40

UST PL-65

Bldg 2-36

UST PL-36

UST PL-39

SWMU 2-15.13
Boiler Valve Pit and USTs

OA 15
Building 2-15
Steam Clean Sump

Bldg 2-123

OA 5
Fuel Station Area

Bldg 2-15

SWMU 2-15.14
Bulk Storage Tank Pit,
Oil/Water Separator, and
Oil Holding Tank

SWMU 78.A
Oil/Water Separator

OA 4
Scattered PCB
Exceedances

AOC 2-10.1AA
Hydraulic Stamp
Machines and Sumps

SWMU 2-15.7A
Waste Storage Tank PL-52

Bldg 2-37

SWMU 2-15.7A
Waste Storage Tank PL-53

OA 4
Scattered PCB
Exceedances

AOC 2-10.3A
North TCE
Degreaser

AOC 2-10.2A
Decommissioned
Machine Sumps

OA 4
Scattered PCB
Exceedances

AOC 2-10.6A
Quench Tank

SWMU 2-10.9
Aluminum Chem
Mill Area

SWMU 2-10.7
Paint Strip Tank Line

AOC 2-10.4A
South TCE Degreaser

AOC 2-10.5
Paint Booth Area

Bldg 2-10

AOC 2-10.5A
Polishing Tank and
Former Paint Booth

AOC 2-10.1AB
Hydraulic Stamp Machines and Sumps

SWMU 2-10.8
Anodic and Alodine
Tank Lines

SWMU 2-10.4
Zyglo Penetrant Spray Booth

OA 8 (SWMU 2-09.2)
Building 2-09
Chrome Waste Tanks
(TSD Unit 4)

DUWAMISH WATERWAY

LEGEND

- Plant 2 Sub-Area Boundary
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- TSD - Treatment Storage and Disposal
- Removed Sump or UST
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area

- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 125
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

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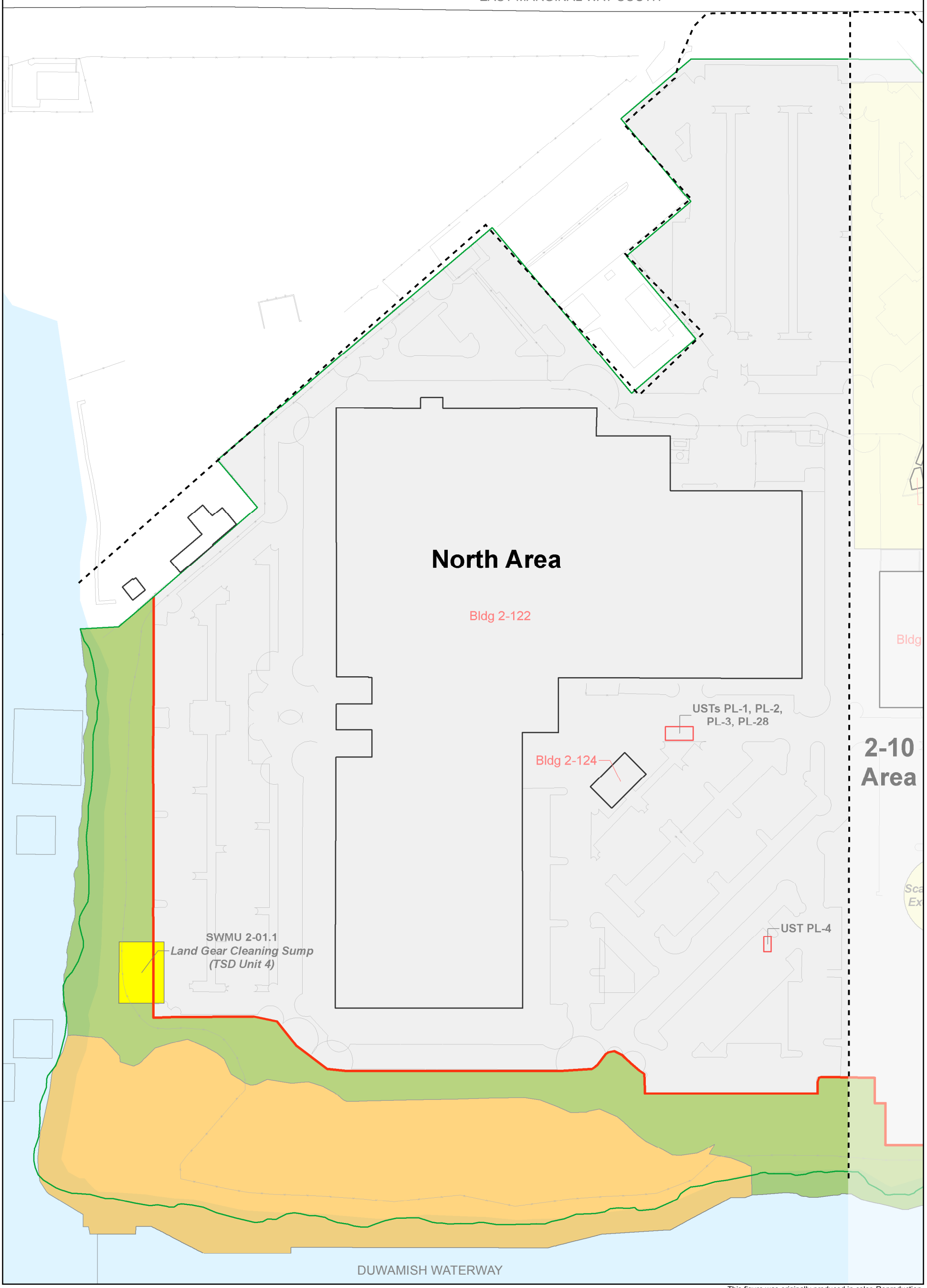
FIGURE **1-9**

BOEING PLANT 2
2-10 AREA

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

Golder Associates

Document Path: G:\Boeing\Plant 2\99_PROJECTS\0131646017_CMS_CONSTRUCTION_SUPPORT\100_CMS_SOB_CMI\02_PRODUCTION\MXD\FIGURES\CMS_Report\Rev0\0131646017_100_009_F1_9_Rev0_2-10Area.mxd Date: 10/25/2017 User: HJackson



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LEGEND

- Plant 2 Sub-Area Boundary
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- TSD - Treatment Storage and Disposal
- Removed Sump or UST
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area

- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 100
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

FIGURE **1-10**
BOEING PLANT 2
NORTH AREA
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

Golder Associates

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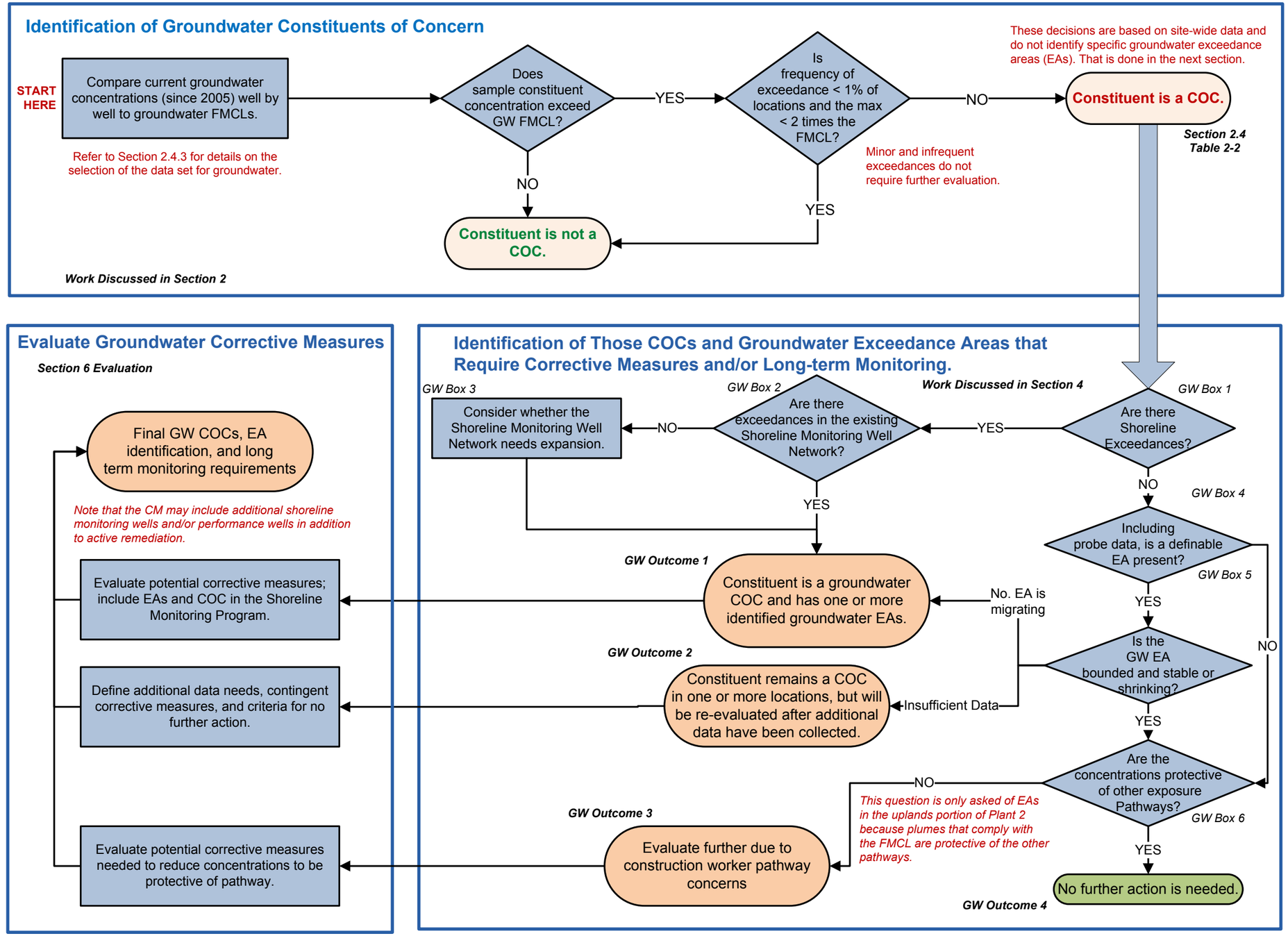
Overall Process Flow

1. Screen site-wide groundwater data set against groundwater FMCLs; if concentration is greater than FMCL, it is a COC.
2. Define groundwater POC as the Shoreline because the FMCL is based in protection of surface water quality.
3. Identify groundwater contamination that reaches or could reasonably reach the POC; these constituents are groundwater COCs and their EAs are evaluated in the CMS (Outcome 1).
4. Identify any additional GW EAs with insufficient information to eliminate and identify data needs and triggers for CM evaluation (Outcome 2).
5. EAs that don't have the potential to reach the POC must be protective of construction worker direct contact. If not protective, then evaluate in CMS (Outcome 3); otherwise, no further action is needed (Outcome 4).



Abbreviations:

CMS	= Corrective Measures Study
COC	= Constituent of concern
COPC	= Constituent of Potential Concern
EA	= Exceedance Area
FMCL	= Final Media Cleanup Level
GW	= Groundwater
POC	= Point of compliance

FIGURE **2-1**

GROUNDWATER SCREENING FLOW CHART

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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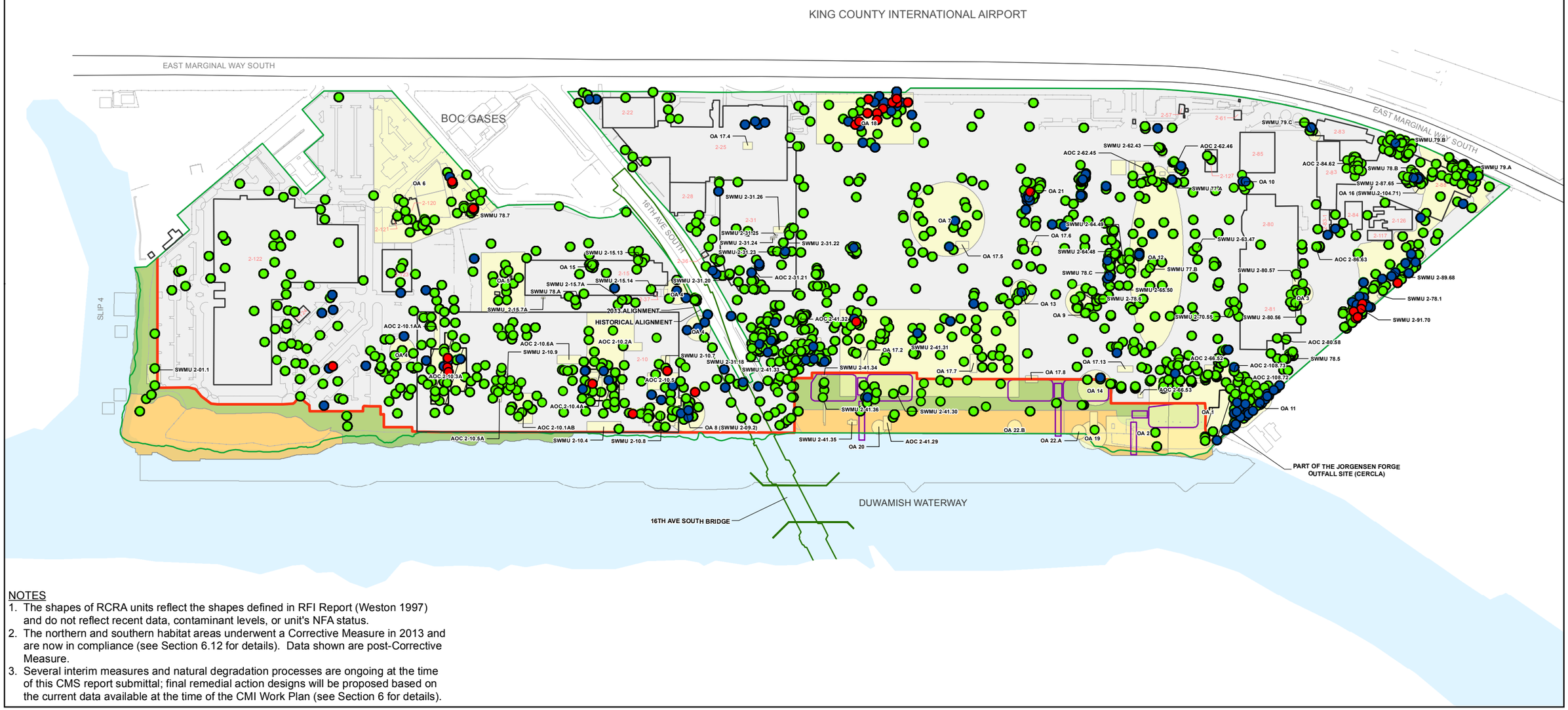
Golder Associates



NOTES

1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. The northern and southern habitat areas underwent a Corrective Measure in 2013 and are now in compliance (see Section 6.12 for details). Data shown are post-Corrective Measure.
3. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

- Detected above FMCL
- Detected above Residential Criteria
- All results below residential criteria and FMCLs
- Non-detect result exceeds residential criteria or FMCL
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area

- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

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FIGURE **2-2**

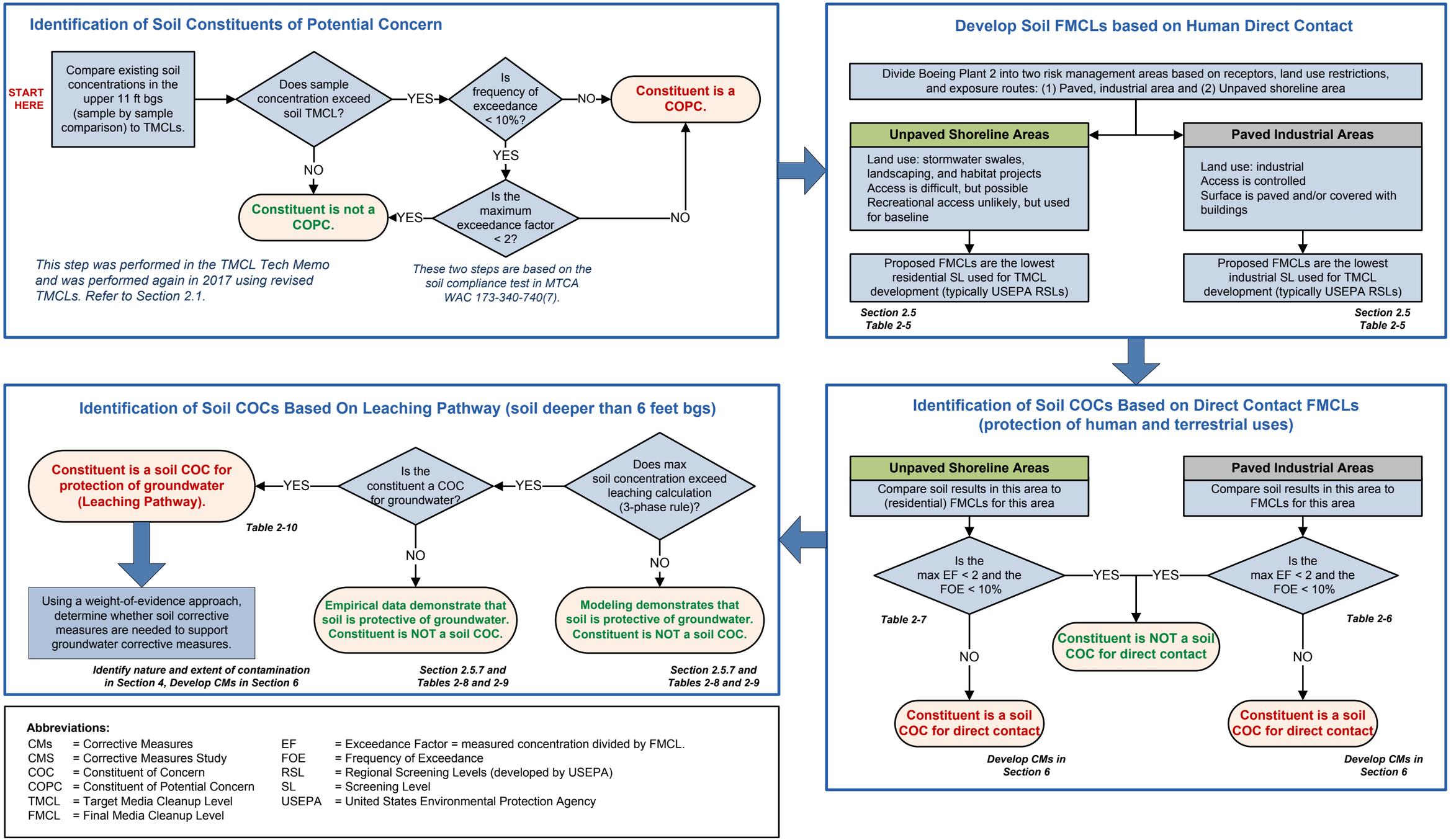
EXCEEDANCES OF RESIDENTIAL AND INDUSTRIAL DIRECT CONTACT MCLS

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

Path: I:\GIS\Projects\BOE-PL2\MXD\2017 CMI TMCL\Figure 2-2 Exceedances of Residential and Industrial Direct Contact MCLs.mxd

Date: 10/26/2017 User: kimr

Floyd|Snider



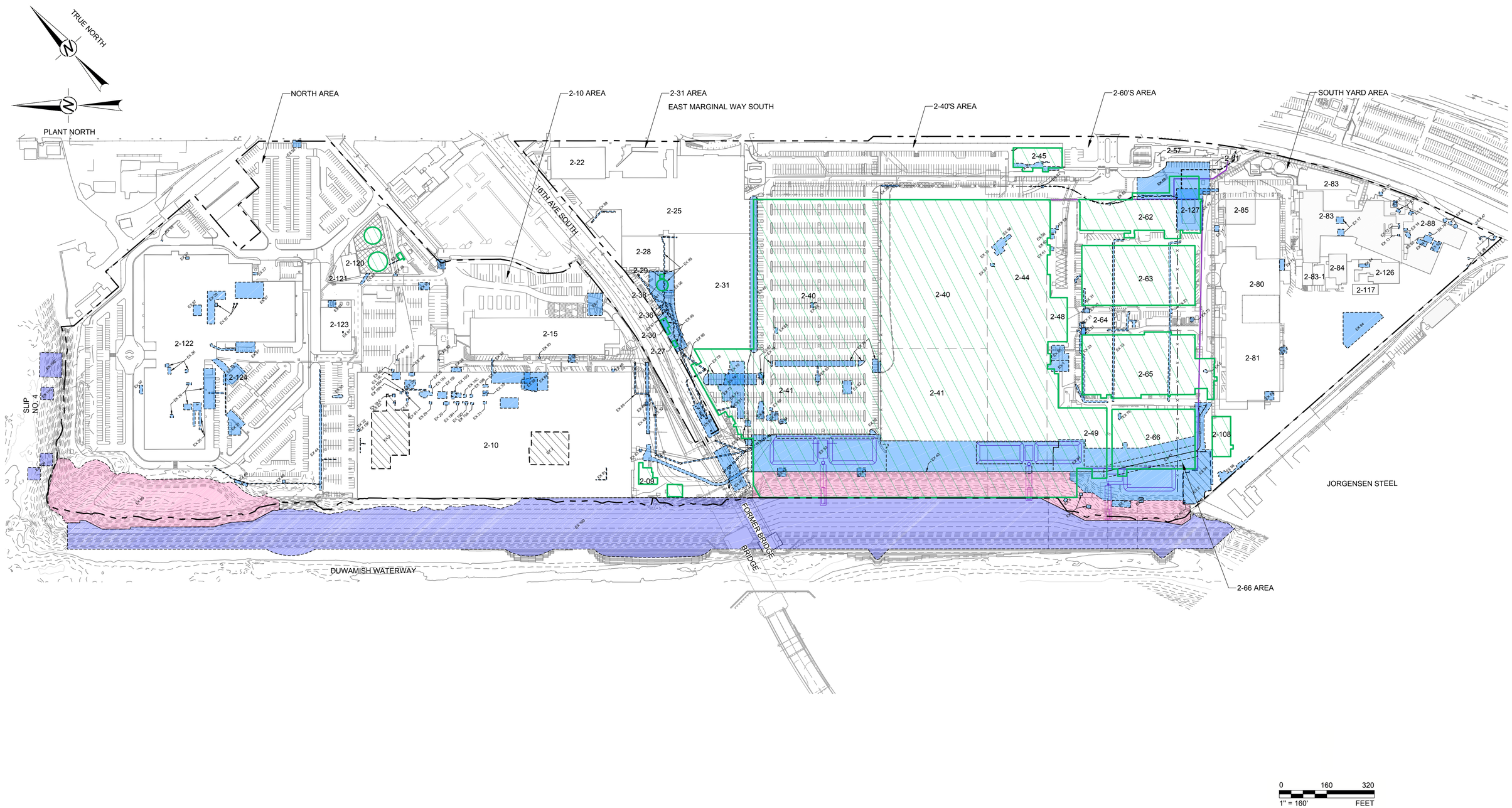
Abbreviations:

CMs	= Corrective Measures	EF	= Exceedance Factor = measured concentration divided by FMCL.
CMS	= Corrective Measures Study	FOE	= Frequency of Exceedance
COC	= Constituent of Concern	RSL	= Regional Screening Levels (developed by USEPA)
COPC	= Constituent of Potential Concern	SL	= Screening Level
TMCL	= Target Media Cleanup Level	USEPA	= United States Environmental Protection Agency
FMCL	= Final Media Cleanup Level		

FIGURE **2-3**

SOIL SCREENING FLOW CHART

BOEING PLANT 2 CORRECTIVE MEASURES STUDY



LEGEND

- PROPERTY BOUNDARY
- DEMOLISHED BUILDING
- 2012 REDEVELOPMENT AREA
- STORMWATER SWALES
- SHEETPILE LOCATION
- X FENCE LINE
- HISTORICAL EXCAVATION AREA
- NORTH / SOUTH SHORELINE AREA
- DSOA AND SOUTHWEST BANK AREA

CLIENT
BOEING

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-24
DESIGNED	REDMOND
PREPARED	REDMOND
REVIEWED	DC
APPROVED	TN

PROJECT
2017 CMS & CONSTRUCTION SUPPORT
BOEING PLANT 2
SEATTLE, WA

TITLE
HISTORICAL EXCAVATION AREAS

PROJECT NO.	PHASE/TASK	REV.	FIGURE
0131646017	100/1	A	3-1

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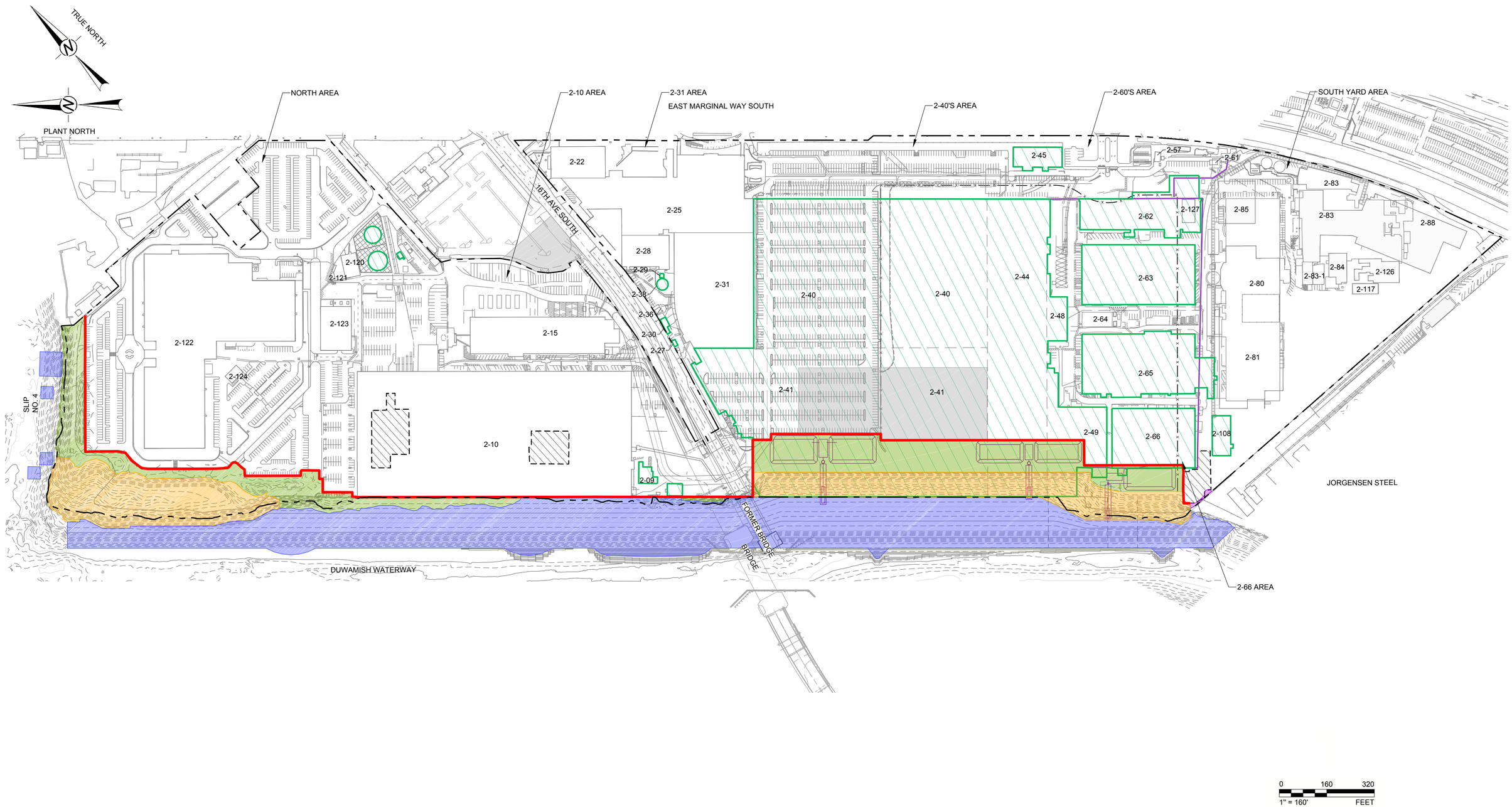

LEGEND

- PROPERTY BOUNDARY
- DEMOLISHED BUILDING
- 2012 REDEVELOPMENT AREA
- STORMWATER SWALES
- SHEETPILE LOCATION
- FENCE LINE
- PAVED INDUSTRIAL / UNPAVED SHORELINE AREA SEPARATION LINE
- PAVED INDUSTRIAL AREA
- DSOA AND SOUTHWEST BANK AREA
- HABITAT PROJECT AREA
- UNPAVED SHORELINE AREA
- PART OF JORGENSEN FORGE OUTFALL SITE (CERCLA)

CLIENT
BOEING

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-24
DESIGNED	REDMOND
PREPARED	REDMOND
REVIEWED	DC
APPROVED	TN

PROJECT
2017 CMS & CONSTRUCTION SUPPORT
BOEING PLANT 2
SEATTLE, WA

TITLE
PLANT 2 CURRENT FEATURES

PROJECT NO.	PHASE/TASK	REV.	FIGURE
0131646017	100/1	A	3-2

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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

EAST MARGINAL WAY SOUTH

2-22
2-25
2-28
2-15
2-10 BLDG
2-31
2-40
2-41
2-44
2-48
2-64 Slab
2-65 SLAB
2-127
2-85
2-83
2-80
2-81
2-84
2-126
2-117
WIND TUNNEL 2-88
EAST MARGINAL WAY S
16TH AVE. SOUTH
Tunnel "A"
Tunnel "C"
SOIL BORROW AREA * FOR BOTTOM OF TUNNEL "A"
SOIL BORROW AREA * FOR BOTTOM OF TUNNEL "C"
SOIL BACKFILL FROM NORTH AREA STORMWATER SYSTEM RETROFIT
SOIL BACKFILL FROM SPU POTHOLES NEAR BLDG 2-15
SOIL BACKFILL FROM DUCT BANK EXCAVATION IN SOUTH PARK BRIDGE AREA
SOIL BACKFILL FROM BLDG 2-25 SANITARY LINE POTHOLES
SOIL BACKFILL FROM GAS LINE EXCAVATION NEAR BLDG 2-15
SHEETPILE CONTAINMENT AREA
SHEETPILE CONTAINMENT STRUCTURE
JORGENSEN STEEL
DUWAMISH COMMERCIAL WATERWAY

LEGEND

- PRE-DEMOLITION LOCATION OF TUNNEL
- DEMOLITION AREA
- SOIL FROM NORTH STORMWATER SYSTEM RETROFIT EXCAVATIONS
- SOIL FROM BLDG 2-25 POTHOLES THAT INVESTIGATED A SANITARY LINE
- SOIL FROM SPU POTHOLES NEAR BLDG 2-15
- SOIL FROM GAS LINE EXCAVATION NEAR BLDG 2-15
- SOIL DUCT BANK EXCAVATION NEAR SOUTH PARK BRIDGE
- BACKFILL FROM SOIL BORROW AREA FOR TUNNEL "A"
- BACKFILL FROM SOIL BORROW AREA FOR TUNNEL "C"
- IMPORTED CLEAN SOIL BACKFILL PURCHASED FROM CITY TRANSFER INC. OR KANGLEY ROCK & RECYCLING (BOTH FROM PIT B-231)
- IMPORTED CLEAN SOIL BACKFILL PURCHASED FROM CADMAN

NOTES

1. SOIL BORROW AREAS IN THE FOOTPRINT OF BLDG 2-40 WERE USED AS THE SOURCE OF CLEAN FILL THAT WAS PLACED IN THE BOTTOM OF THE TUNNEL EXCAVATIONS TO AN ELEVATION APPROXIMATELY 1.5 FEET ABOUT THE GROUNDWATER TABLE.
2. BUILDINGS AND SLABS WERE REMOVED (EXCEPT AS INDICATED) IN THE DEMOLITION/REDEVELOPEMENT AREA. BUILDING AND SLAB NUMBERS ARE FOR REFERENCE ONLY.
3. SPU = SEATTLE PUBLIC UTILITIES.

TRUE NORTH

PLANT NORTH

0 100 200
SCALE FEET

CLIENT
BOEING

CONSULTANT
Golder Associates

YYYY-MM-DD	2014-06-25
PREPARED	REDMOND
DESIGN	SES
REVIEW	DC
APPROVED	TN

PROJECT
CMS REPORT
BOEING PLANT 2
SEATTLE, WA

TITLE
PLANT 2 SOIL BACKFILL LOCATIONS AS OF NOVEMBER 30, 2011

PROJECT No.	CONTROL	Rev.	FIGURE
0131646014	600	0	3-3

Path: \\redmond.golder.gds\gecomat\$\geomatics\Boeing\Plant 2\99_PROJECTS\0131646014_CMS_CONSTRUCTION_SUPPORT\600_CMS_SOB_SMI\02_PRODUCTION\DWG\ | File Name: Crushed Concrete Sampling & Density-r4.dwg

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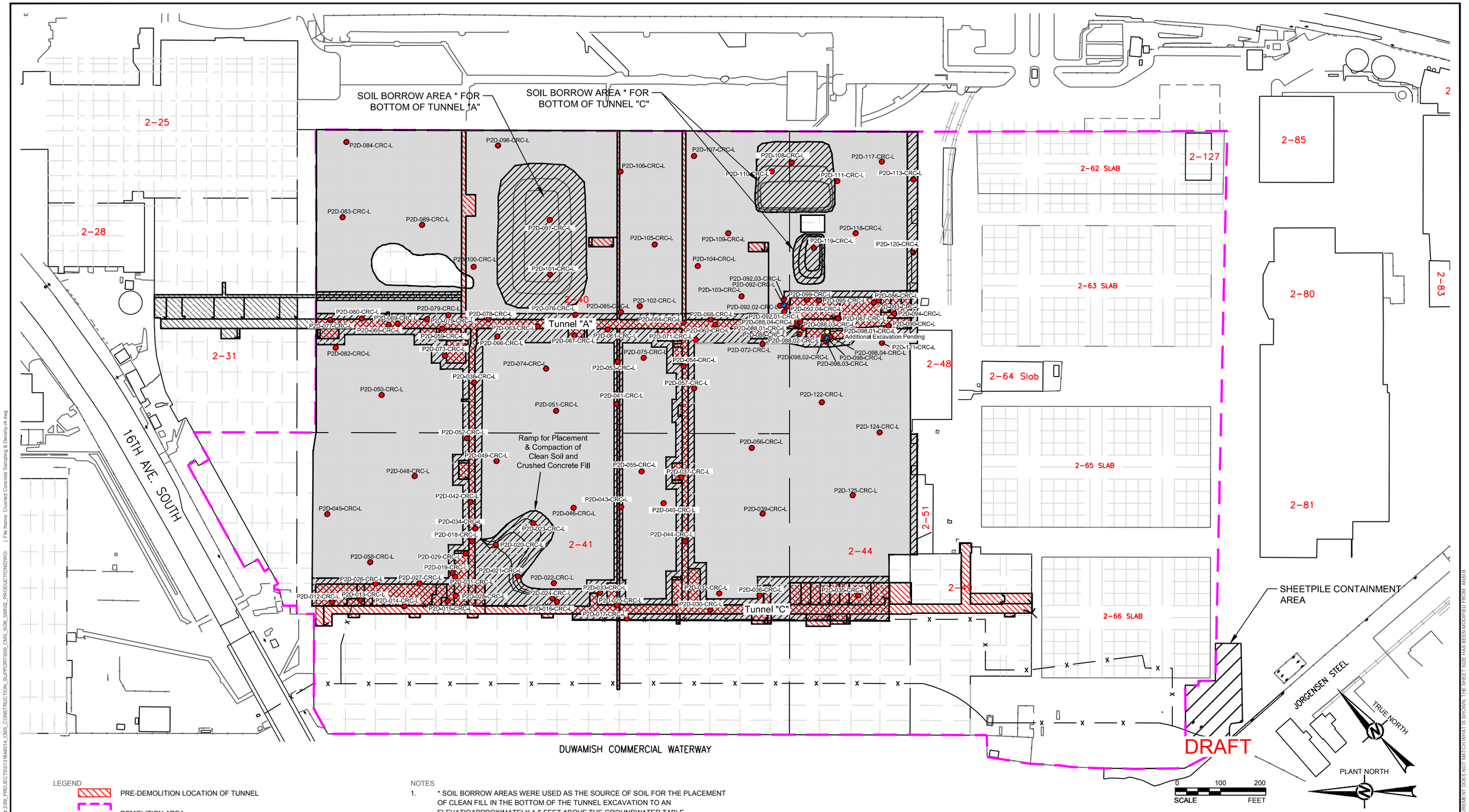


LEGEND

- PRE-DEMOLITION LOCATION OF TUNNEL
- DEMOLITION AREA
- CRUSHED CONCRETE SURFACE-LEVELING FILL: THICKNESS 0 TO 1.5 ft.
- CRUSHED CONCRETE BACKFILL: THICKNESS 2 TO 8 ft.
- P2D-012-CRC-L — CRUSHED CONCRETE LAB SAMPLE LOCATION
- P2D-092-CRC-L — CRUSHED CONCRETE LAB SAMPLE LOCATION, >10ppm PCBs AND WAS REMOVED
- P2D-098.01-CRC-L — CRUSHED CONCRETE LAB SAMPLE LOCATION, >10 ppm PCBs - REMOVAL EXCAVATION PENDING

NOTES

1. * SOIL BORROW AREAS WERE USED AS THE SOURCE OF SOIL FOR THE PLACEMENT OF CLEAN FILL IN THE BOTTOM OF THE TUNNEL EXCAVATION TO AN ELEVATIOAPPROXIMATELY 1.5 FEET ABOVE THE GROUNDWATER TABLE.
2. BUILDINGS AND SLABS WERE REMOVED (EXCEPT AS INDICATED) IN THE DEMOLITION/REDEVELOPEMENT AREA. BUILDING AND SLAB NUMBERS ARE FOR REFERENCE ONLY.

CLIENT
BOEING

CONSULTANT
Golder Associates

YYYY-MM-DD	2014-06-25
PREPARED	REDMOND
DESIGN	SES
REVIEW	DC
APPROVED	TN

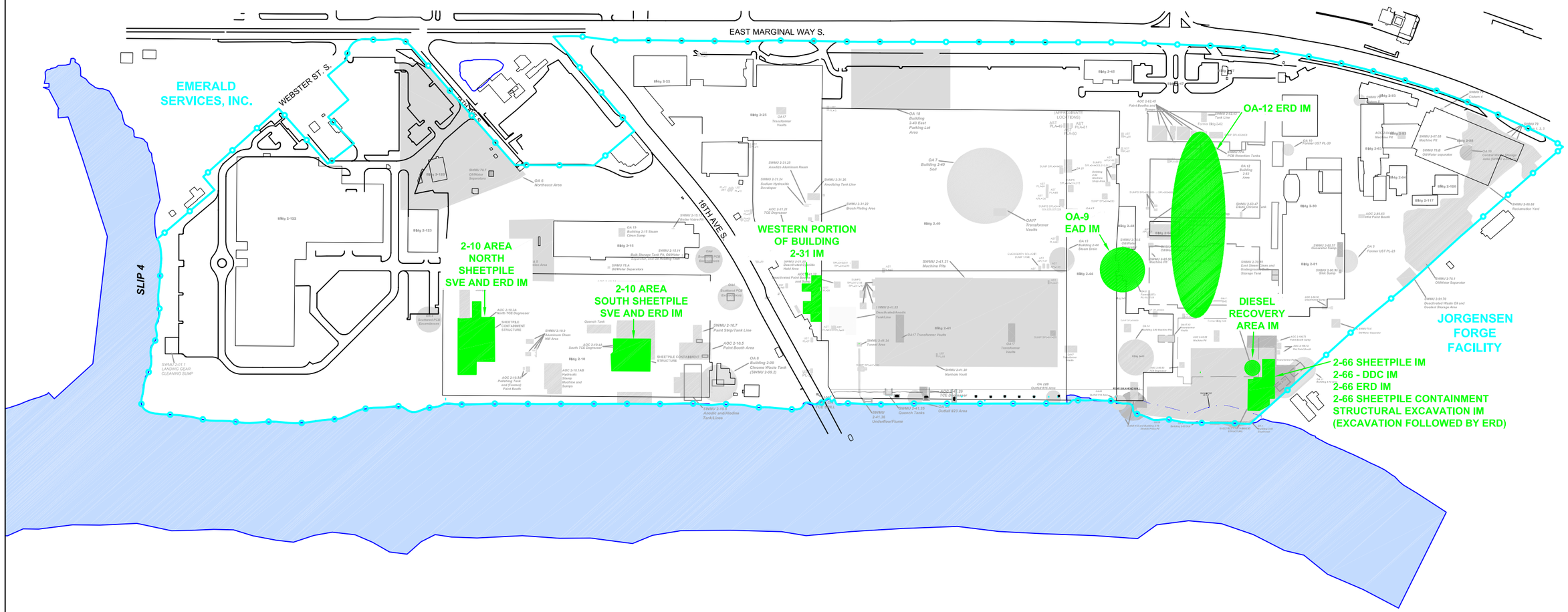
PROJECT
CMS REPORT
BOEING PLANT 2
SEATTLE, WA

TITLE
CRUSHED CONCRETE BACKFILL AND SAMPLE LOCATIONS AS OF DECEMBER 14, 2011

PROJECT No.	CONTROL	Rev.	FIGURE
0131646014	600	0	3-4

Path: \\redmond.golder.gds\gecomat$\geomatics\Boeing\Plant 2\09_PROJECTS\0131646014_CMS_CONSTRUCTION_SUPPORT\600_CMS_SOB_SMI\02_PRODUCTION\DWG\ | File Name: Crushed Concrete Sampling & Density-r4.dwg
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

KING COUNTY INTERNATIONAL AIRPORT



KEY:

N

PROPERTY BOUNDARY

APPROXIMATE LOCATION OF GROUNDWATER INTERIM MEASURE

0 87.5 175 350

SCALE: 1" = 350'

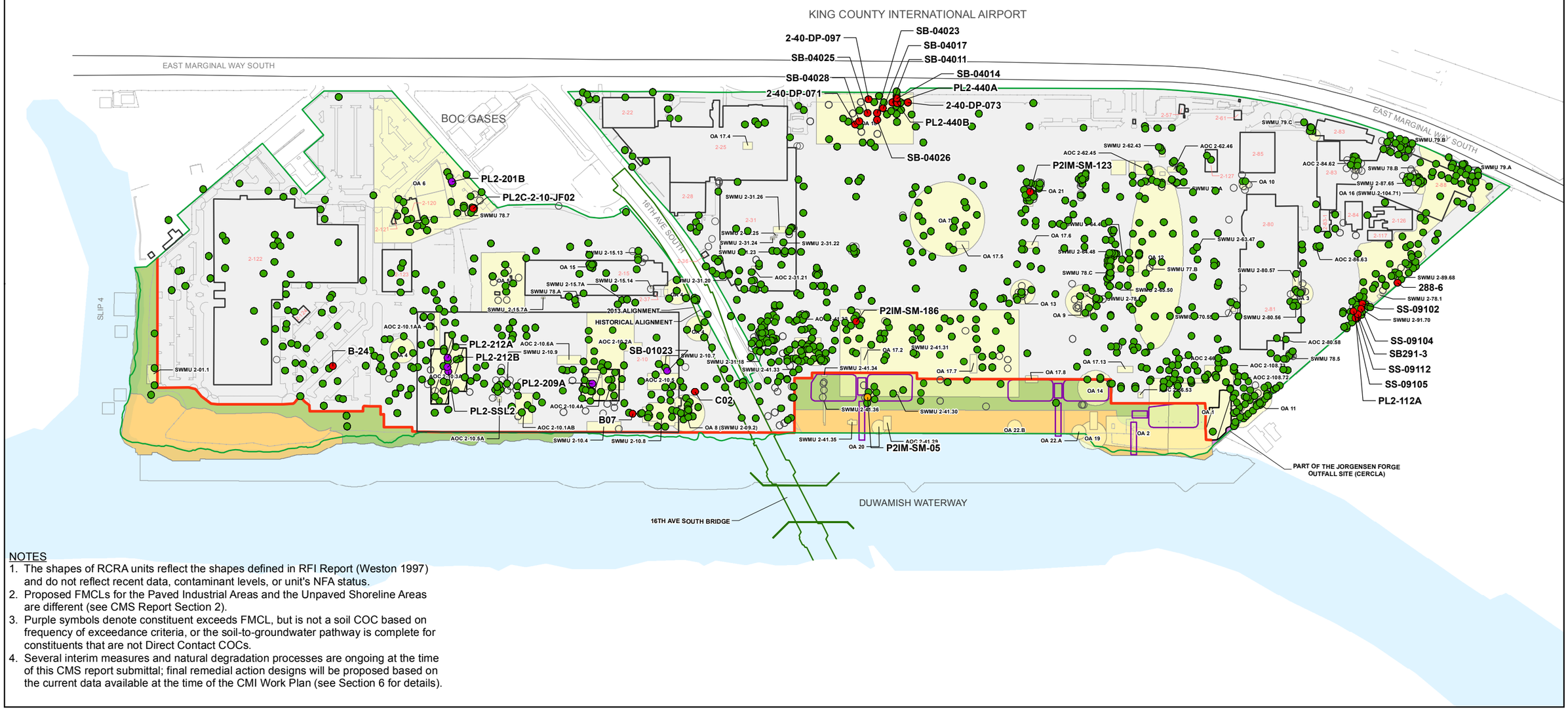
DDC - DENSITY DRIVEN CONVECTION
EAD - ENHANCED AEROBIC DEGRADATION
ERD - ENHANCED REDUCTIVE DECHLORINATION
IM - INTERIM MEASURE
SVE - SOIL VAPOR EXTRACTION

PROJECT	BOEING PLANT 2 CMS VOL. X		
PREPARED FOR	THE BOEING COMPANY		
LOCATION	7725 EAST MARGINAL WAY SEATTLE/TUKWILA, WASHINGTON		
SHEET 1 of 1	DRAWN BY ARM	REVIEWED BY DCK	DATE 02/25/14

ENVIRONMENTAL PARTNERS INC
295 NE Gilman Boulevard, Suite 201
Issaquah, Washington 98027

FIGURE 3-5

GENERAL LOCATIONS OF GROUNDWATER INTERIM MEASURES



NOTES

1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. Purple symbols denote constituent exceeds FMCL, but is not a soil COC based on frequency of exceedance criteria, or the soil-to-groundwater pathway is complete for constituents that are not Direct Contact COCs.
4. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels

- Non-detect
- Detected Below Proposed FMCL
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area

- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

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FIGURE **4-1**

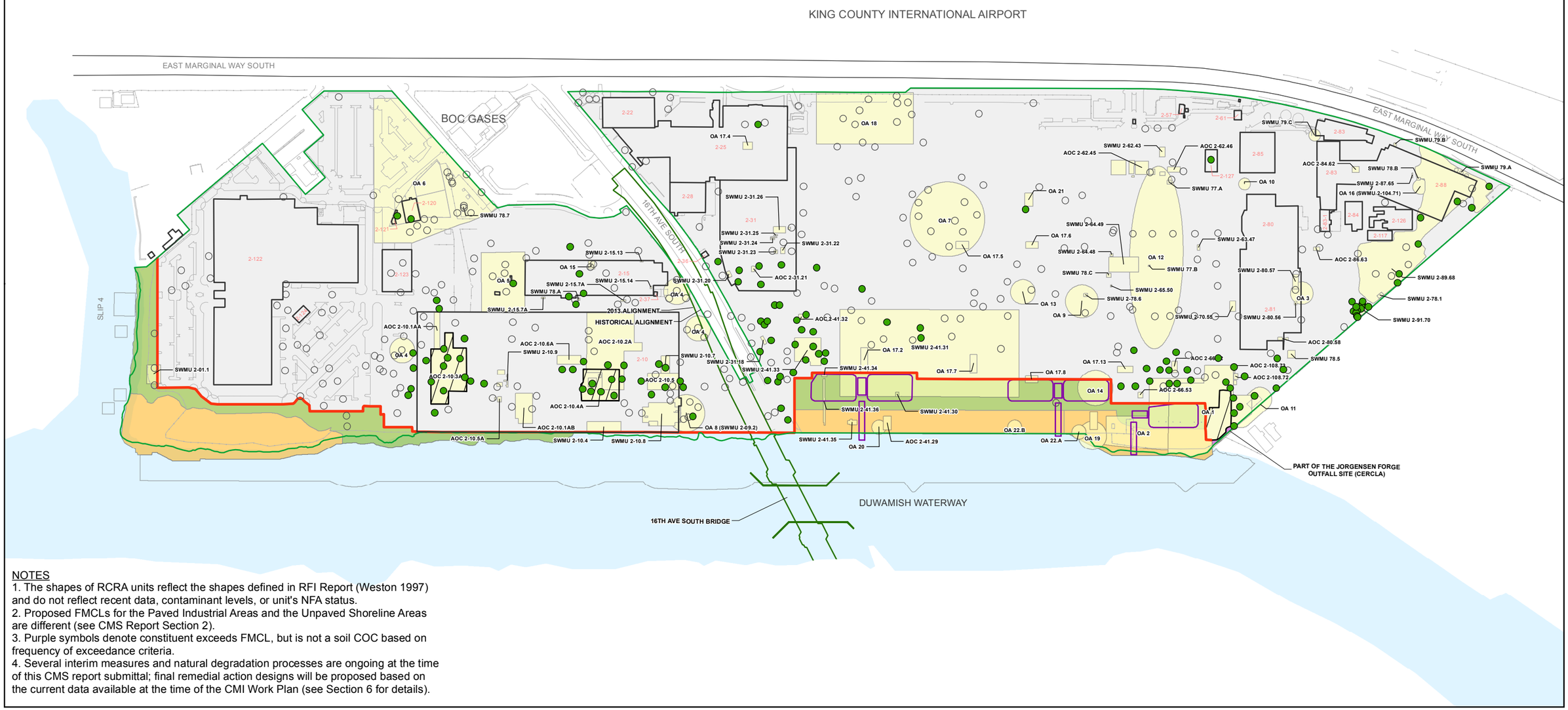
BOEING PLANT 2

SOIL DATA (0-11 FEET) FMCL EXCEEDANCES

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

Path: G:\Boeing\Plant 2\99_PROJECTS\0131646017_CMS_CONSTRUCTION_SUPPORT\100_CMS_SOB_CMI\02_PRODUCTION\MXD\FIGURES\CMS_Report\Rev0\0131646017_100_019_F4_1_Rev0_SoilLocationsFMCLExceedances.mxd Date: 11/1/2017 User: HJackson

Golder Associates



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. Purple symbols denote constituent exceeds FMCL, but is not a soil COC based on frequency of exceedance criteria.
4. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

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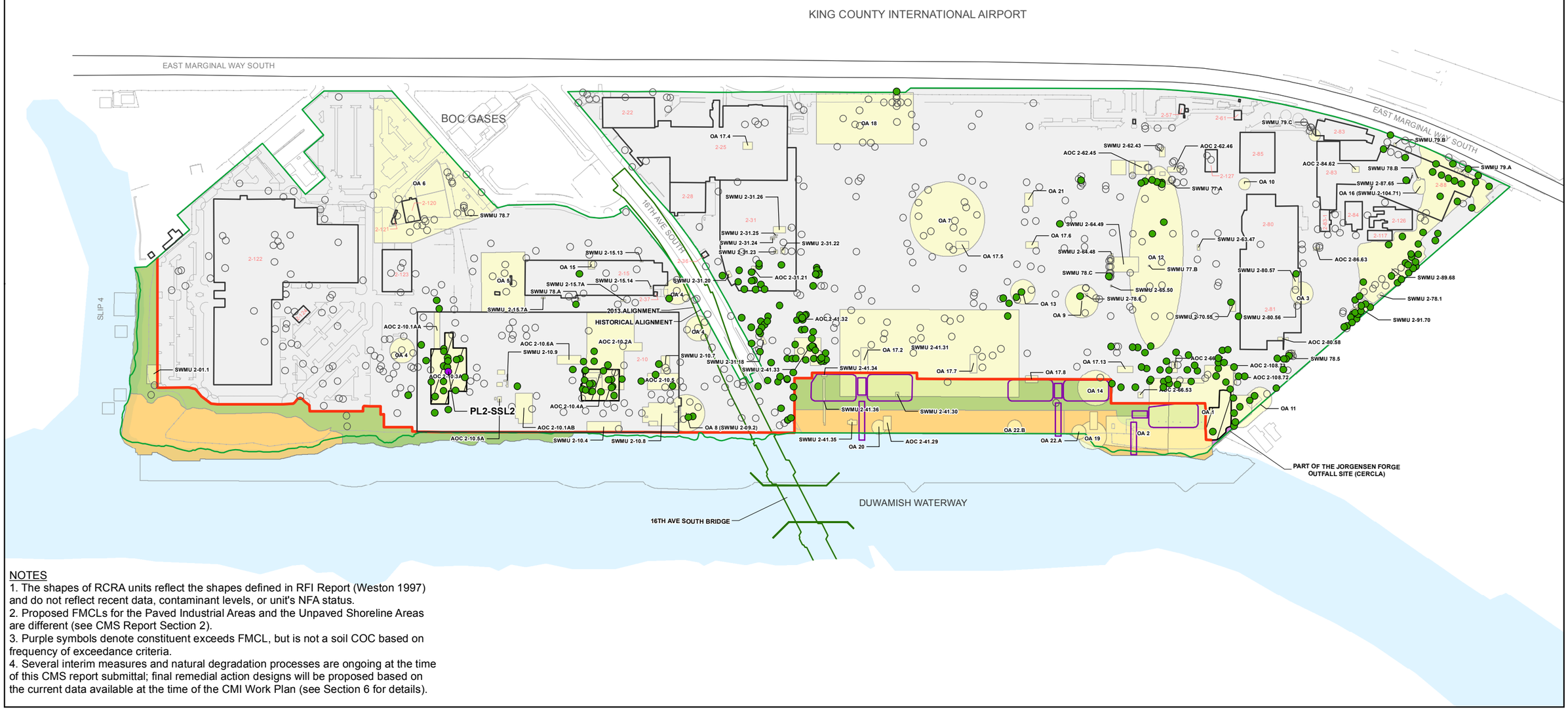
FIGURE **4-2A**
CHLORINATED VOCs SOIL DATA (0-1 FEET)
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

Path: G:\Boeing\Plant 2\99_PROJECTS\0131646017_CMS_CONSTRUCTION_SUPPORT\100_CMS_SOB_CMI\02_PRODUCTION\MXD\FIGURES\CMS_Report\Rev0\0131646017_100_020_F4_2A_Rev0_cVOC_0_1.mxd Date: 11/2/2017 User: HJackson

Golder Associates



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. Purple symbols denote constituent exceeds FMCL, but is not a soil COC based on frequency of exceedance criteria.
4. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

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FIGURE **4-2B**
CHLORINATED VOCs SOIL DATA (1-6 FEET)
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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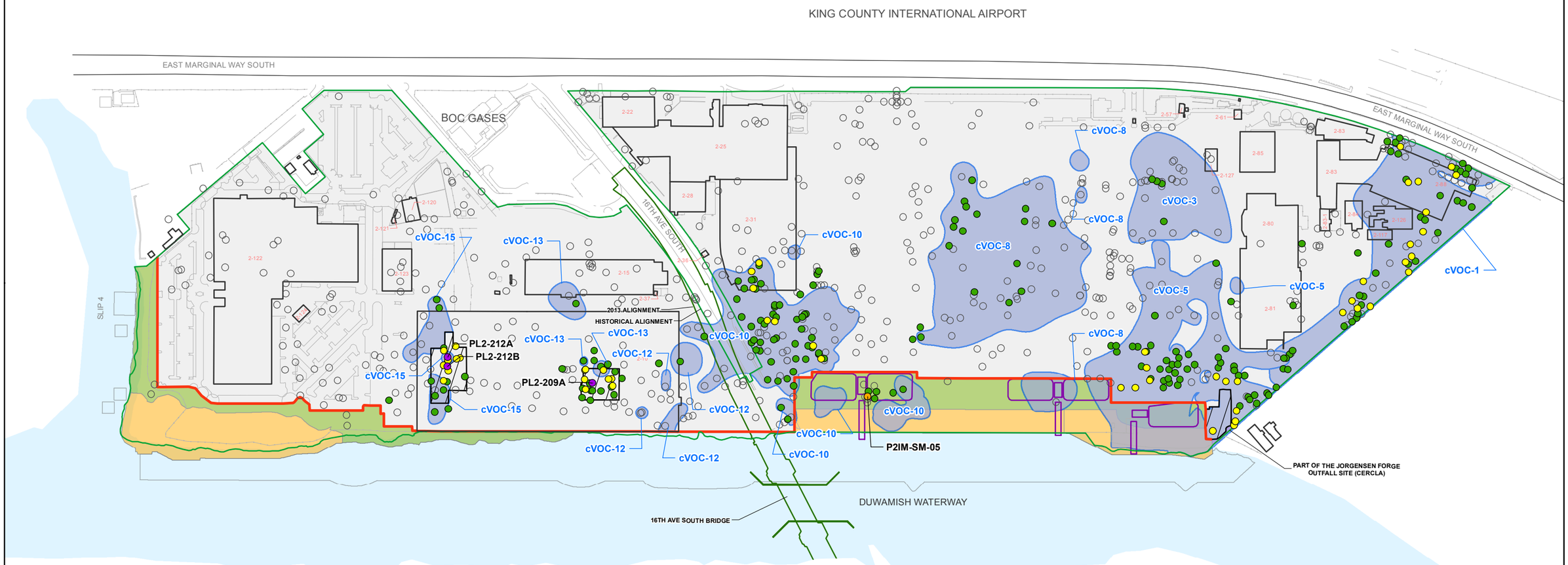
Golder Associates



NOTES
1. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
2. Yellow symbols denote Leaching Screening Levels, see Table 2-6 Leaching Component of the TMCL.
3. Purple symbols denote constituent exceeds FMCL, but is not a soil COC based on frequency of exceedance criteria.
4. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- A-Level Groundwater Exceedance Area
- **cVOC-1** Exceedance Area Identifier
- Stormwater Swale

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **4-2C**

SOIL DATA (6-11 FEET) AND A-LEVEL GROUNDWATER EXCEEDANCE AREAS CONCENTRATIONS COMPARED TO CLEANUP LEVELS FOR CHLORINATED VOCs

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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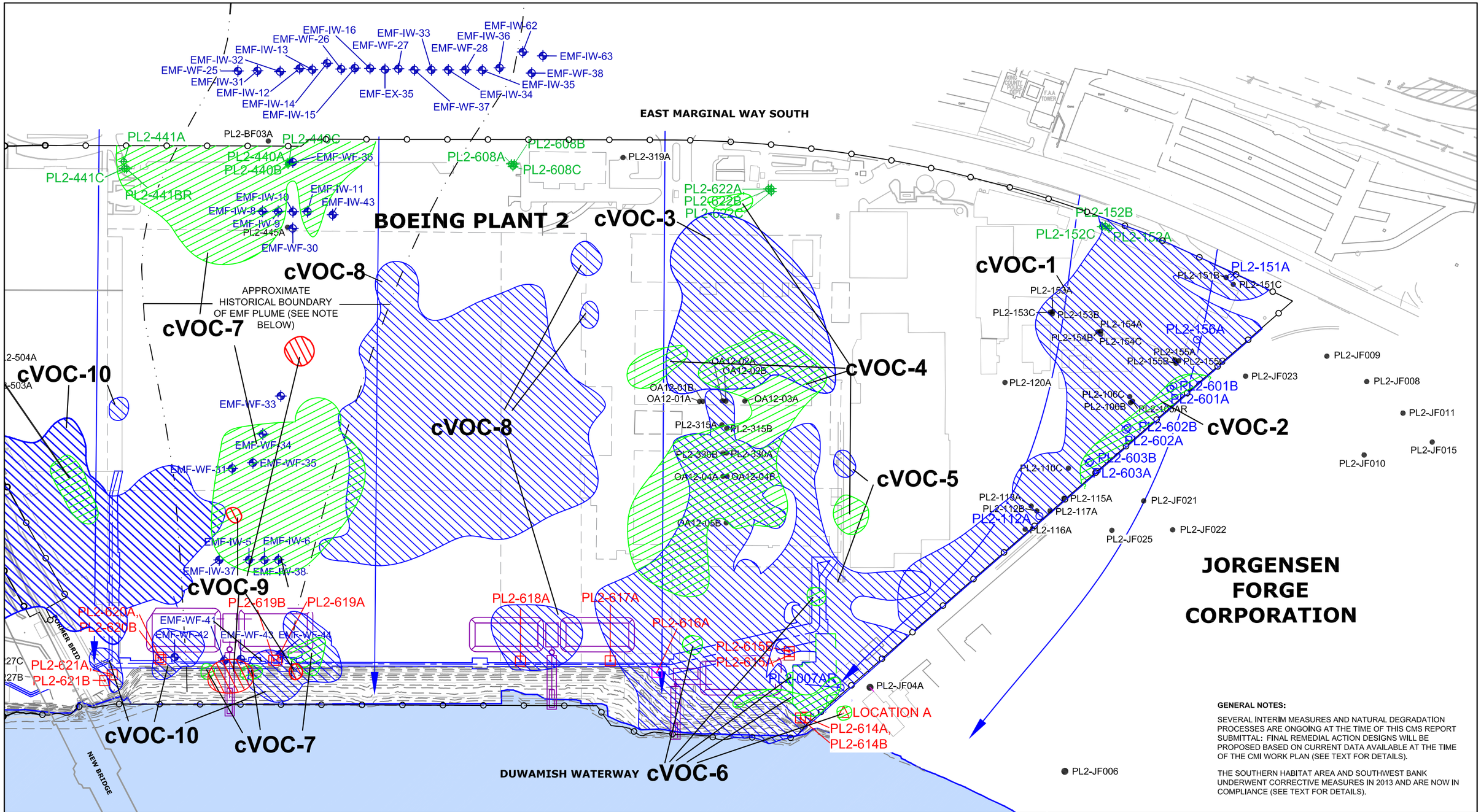
Golder Associates



GENERAL NOTES:

SEVERAL INTERIM MEASURES AND NATURAL DEGRADATION PROCESSES ARE ONGOING AT THE TIME OF THIS CMS REPORT SUBMITTAL: FINAL REMEDIAL ACTION DESIGNS WILL BE PROPOSED BASED ON CURRENT DATA AVAILABLE AT THE TIME OF THE CMI WORK PLAN (SEE TEXT FOR DETAILS).

THE SOUTHERN HABITAT AREA AND SOUTHWEST BANK UNDERWENT CORRECTIVE MEASURES IN 2013 AND ARE NOW IN COMPLIANCE (SEE TEXT FOR DETAILS).

KEY:

- PROPOSED NEW SHORELINE MONITORING WELL
- CURRENT SHORELINE MONITORING WELL
- CURRENT SHORELINE MONITORING WELL NOT PROPOSED FOR FUTURE SHORELINE MONITORING
- UPGRADIENT MONITORING WELL
- PROPERTY BOUNDARY MONITORING WELL
- CURRENT EMF WELL (IW = INJECTION WF = MONITORING)
- OTHER EXISTING WELL
- PROPERTY LINE AS SPECIFIED IN AGREED ORDER
- EMF PLUME - BASED ON 2001-2002 TRANSECT DATA
- BUILDINGS
- FORMER BUILDINGS
- DUCT BANK
- SHEETPILE CONTAINMENT STRUCTURE
- STORMWATER SWALES
- A-LEVEL EXCEEDANCES
- B-LEVEL EXCEEDANCES
- C-LEVEL EXCEEDANCES

THIS FIGURE WAS ORIGINALLY PRODUCED IN COLOR. REPRODUCTION IN BLACK AND WHITE MAY RESULT IN LOSS OF INFORMATION.

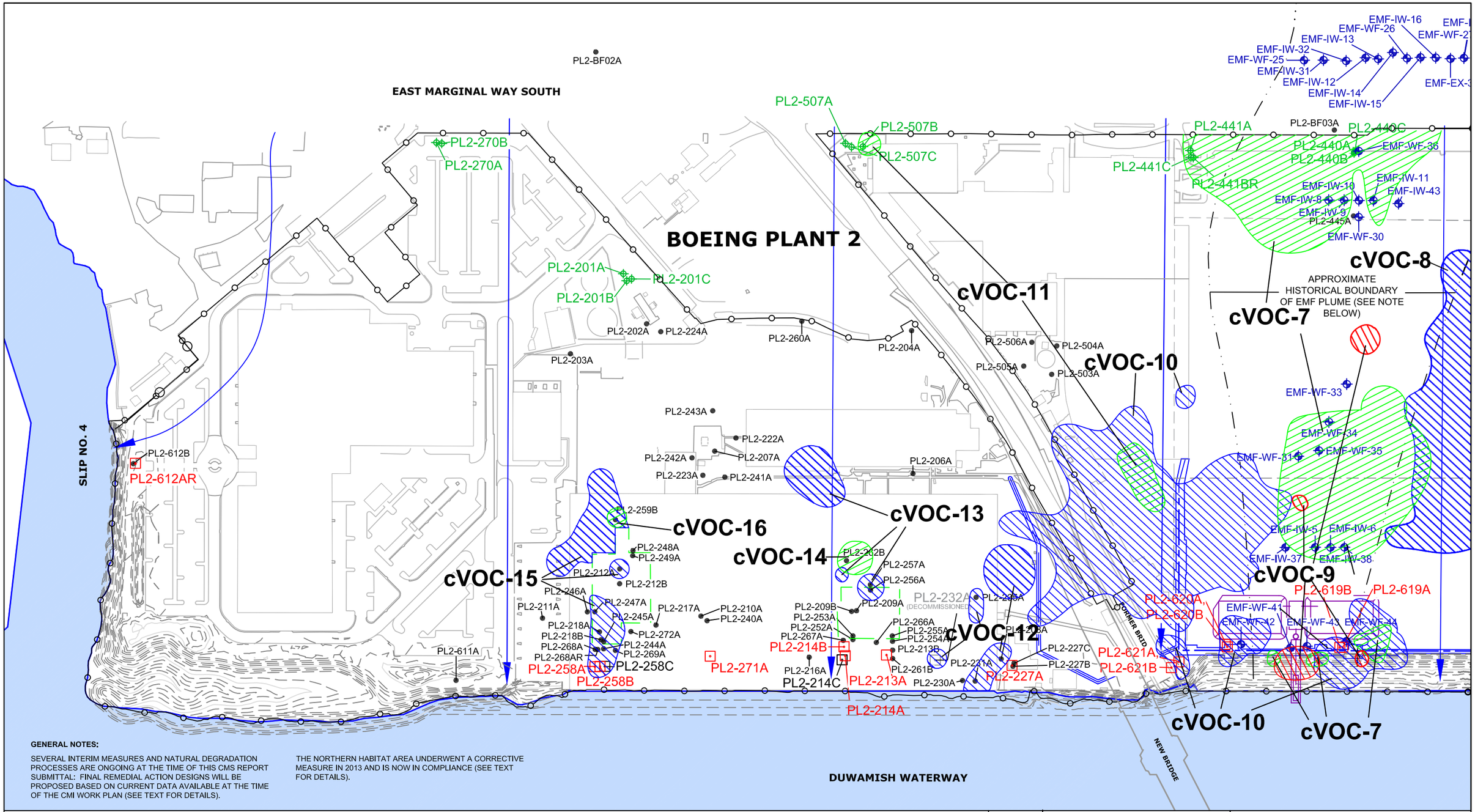
APPROXIMATE GROUNDWATER FLOW DIRECTION BASED ON RCRA FACILITY GROUNDWATER INVESTIGATION INTERIM REPORT, VOLUME V (WESTON, 1996) AND CONCEPTUAL HYDROLOGIC MODEL DATA GAP INVESTIGATION RESULTS (EPI, 2005)

NOTE: FOOTPRINT OF HISTORICAL EMF PLUME (2001 TIMEFRAME). REMEDIAL ACTIONS IMPLEMENTED HAVE REDUCED BOUNDARIES OF THE PLUME FROM THIS HISTORICAL FOOTPRINT.

PROJECT	BOEING PLANT 2		
PREPARED FOR	THE BOEING COMPANY		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILA, WASHINGTON		
SHEET 1 of 1	DRAWN BY VPB	REVIEWED BY DCK	DATE 10/17/17

ENVIRONMENTAL PARTNERS INC
1180 NW Maple Street, Suite 310
Issaquah, Washington 98027

FIGURE 4-2D
AREAS WITH CHLORINATED VOC CONCENTRATIONS EXCEEDING PROPOSED FMCLs
SOUTH PLANT 2



GENERAL NOTES:

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THE NORTHERN HABITAT AREA UNDERWENT A CORRECTIVE MEASURE IN 2013 AND IS NOW IN COMPLIANCE (SEE TEXT FOR DETAILS).

KEY:

- PROPOSED NEW SHORELINE MONITORING WELL
- CURRENT SHORELINE MONITORING WELL
- CURRENT SHORELINE MONITORING WELL NOT PROPOSED FOR FUTURE SHORELINE MONITORING
- UPGRADIENT MONITORING WELL
- PROPERTY BOUNDARY MONITORING WELL
- CURRENT EMF WELL (IW = INJECTION WF = MONITORING)
- OTHER EXISTING WELL
- PROPERTY LINE AS SPECIFIED IN AGREED ORDER
- EMF PLUME - BASED ON 2001-2002 TRANSECT DATA
- BUILDINGS
- FORMER BUILDINGS
- DUCT BANK
- SHEETPILE CONTAINMENT STRUCTURE
- STORMWATER SWALES
- A-LEVEL EXCEEDANCES
- B-LEVEL EXCEEDANCES
- C-LEVEL EXCEEDANCES

0 50 100 200

SCALE: 1" = 200'

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APPROXIMATE GROUNDWATER FLOW DIRECTION BASED ON RCRA FACILITY GROUNDWATER INVESTIGATION INTERIM REPORT, VOLUME V (WESTON, 1996) AND CONCEPTUAL HYDROLOGIC MODEL DATA GAP INVESTIGATION RESULTS (EPI, 2005)

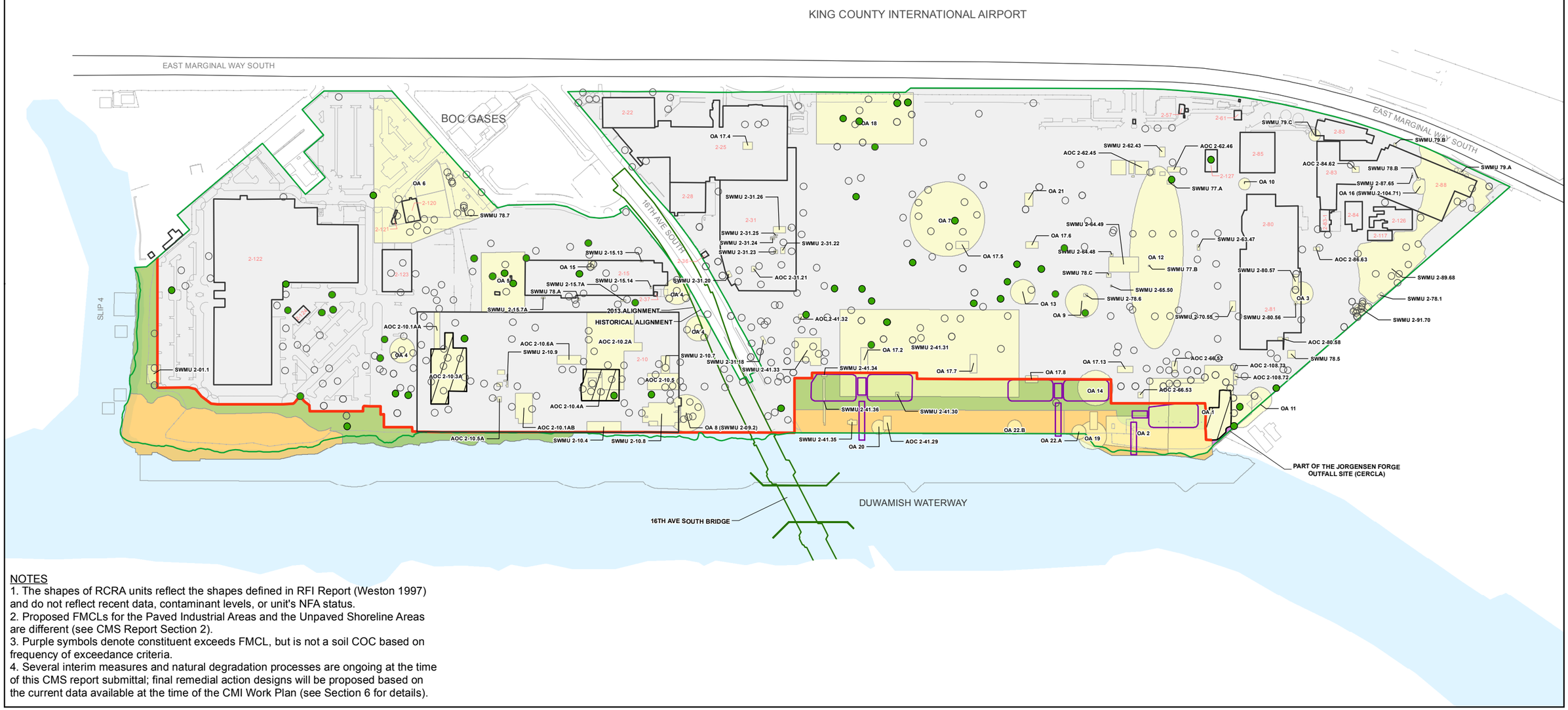
NOTE: FOOTPRINT OF HISTORICAL EMF PLUME (2001 TIMEFRAME). REMEDIAL ACTIONS IMPLEMENTED HAVE REDUCED BOUNDARIES OF THE PLUME FROM THIS HISTORICAL FOOTPRINT.

PROJECT	BOEING PLANT 2		
PREPARED FOR	THE BOEING COMPANY		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILA, WASHINGTON		
SHEET 1 of 1	DRAWN BY VPB	REVIEWED BY DCK	DATE 10/17/17

ENVIRONMENTAL PARTNERS INC
1180 NW Maple Street, Suite 310
Issaquah, Washington 98027

FIGURE 4-2E

AREAS WITH CHLORINATED VOC CONCENTRATIONS EXCEEDING PROPOSED FMCLs NORTH PLANT 2



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. Purple symbols denote constituent exceeds FMCL, but is not a soil COC based on frequency of exceedance criteria.
4. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

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FIGURE **4-3A**
BTEX OR GRPH SOIL DATA (0-1 FEET)
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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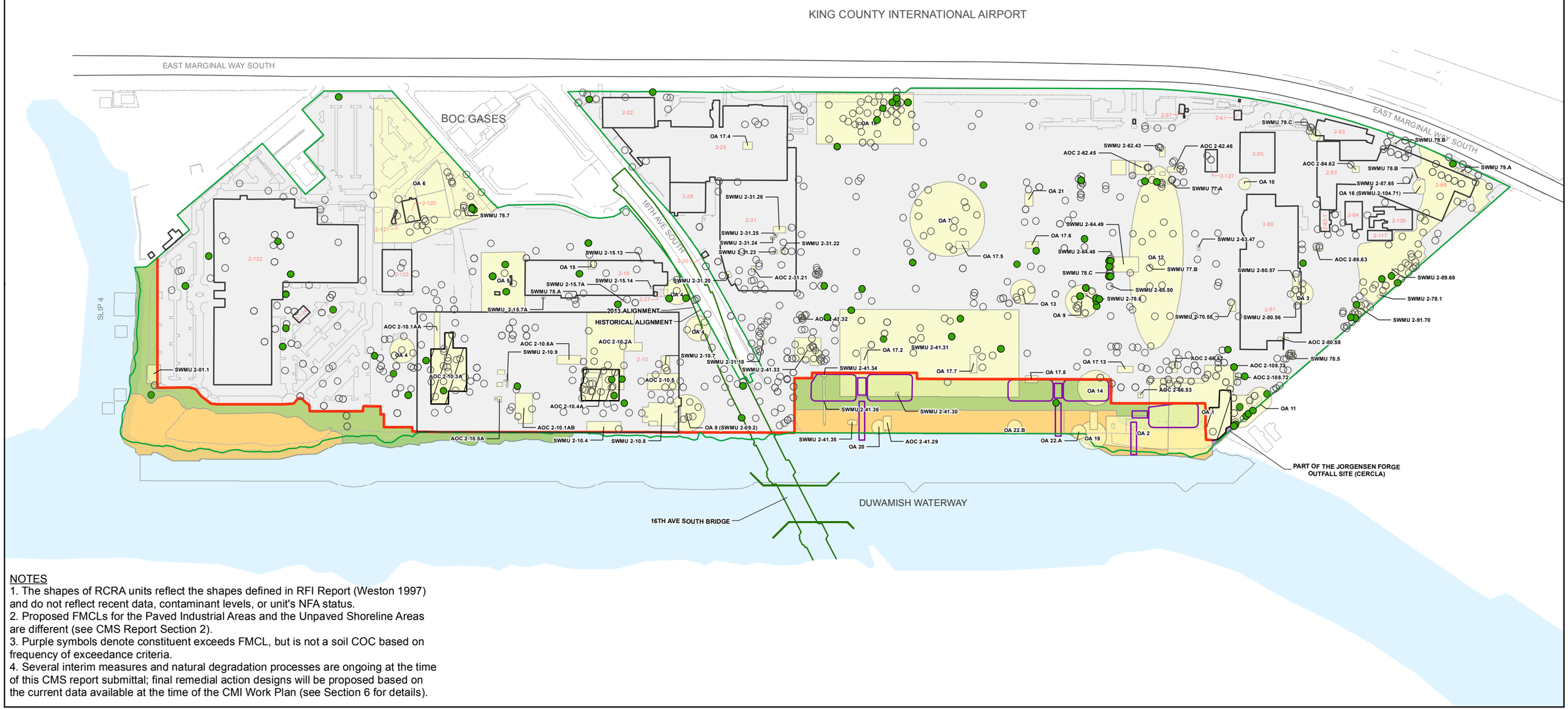
Golder Associates



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. Purple symbols denote constituent exceeds FMCL, but is not a soil COC based on frequency of exceedance criteria.
4. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

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FIGURE **4-3B**
BTEX OR GRPH SOIL DATA (1-6 FEET)
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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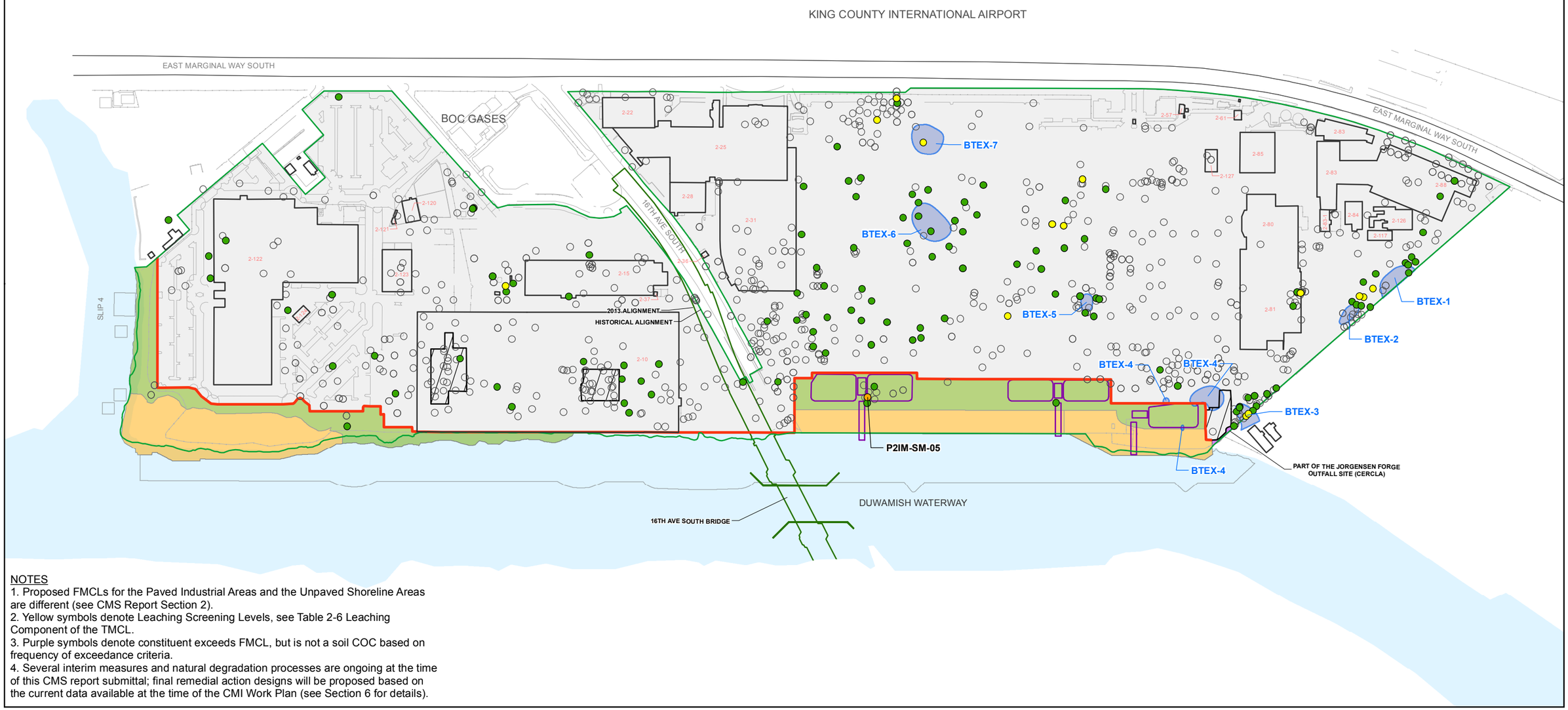
Golder Associates



NOTES
1. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
2. Yellow symbols denote Leaching Screening Levels, see Table 2-6 Leaching Component of the TMCL.
3. Purple symbols denote constituent exceeds FMCL, but is not a soil COC based on frequency of exceedance criteria.
4. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- A-Level Groundwater Exceedance Area
- **BTEX-1** Exceedance Area Identifier
- Stormwater Swale

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

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FIGURE **4-3C**

SOIL DATA (6-11 FEET) AND A-LEVEL GROUNDWATER EXCEEDANCE AREAS CONCENTRATIONS COMPARED TO CLEANUP LEVELS FOR BTEX OR GRPH

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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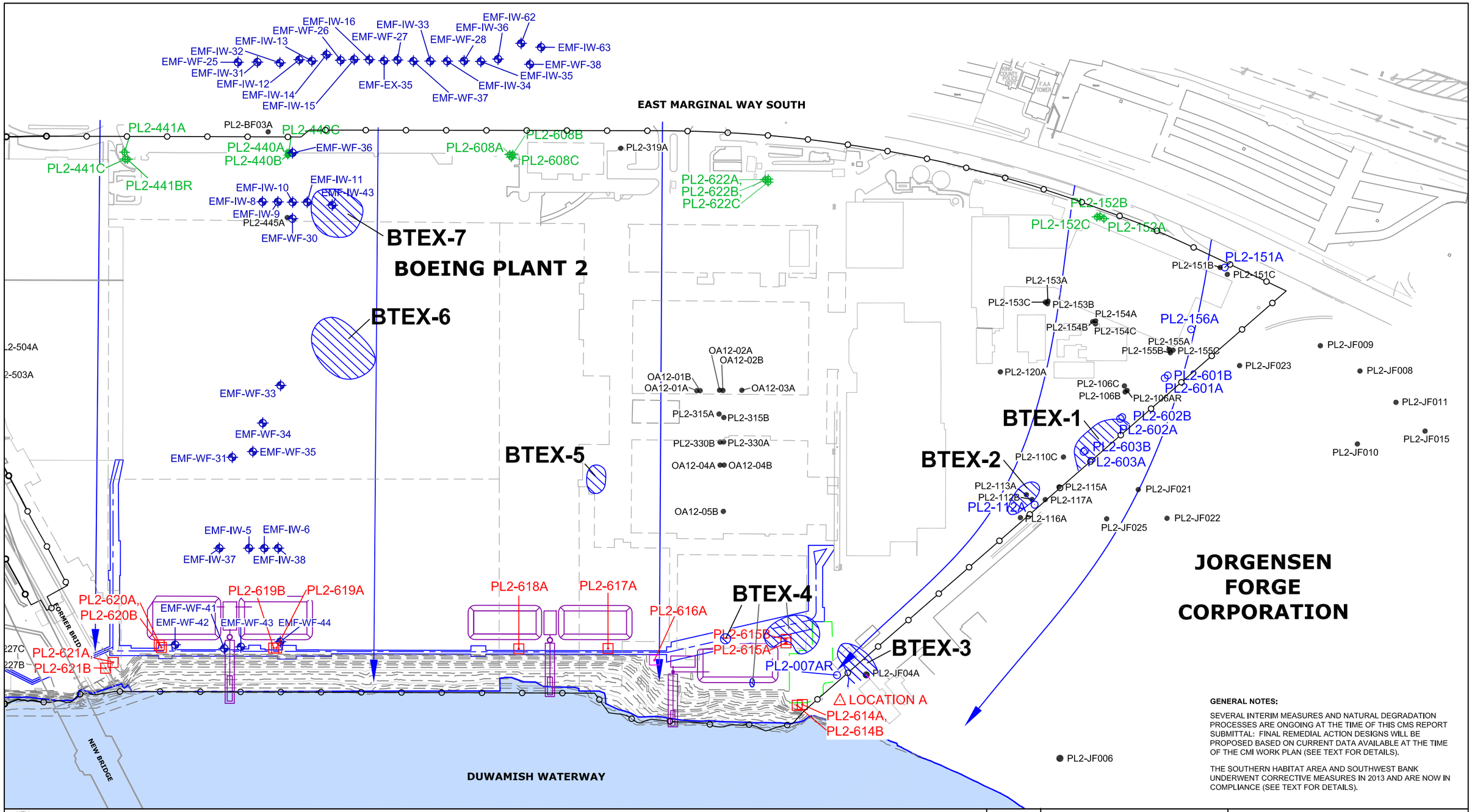
Golder Associates



THIS FIGURE WAS ORIGINALLY PRODUCED IN COLOR. REPRODUCTION IN BLACK AND WHITE MAY RESULT IN LOSS OF INFORMATION.

APPROXIMATE GROUNDWATER FLOW DIRECTION BASED ON RCRA FACILITY GROUNDWATER INVESTIGATION INTERIM REPORT, VOLUME V (WESTON, 1996) AND CONCEPTUAL HYDROLOGIC MODEL DATA GAP INVESTIGATION RESULTS (EPI, 2005)

GENERAL NOTES:

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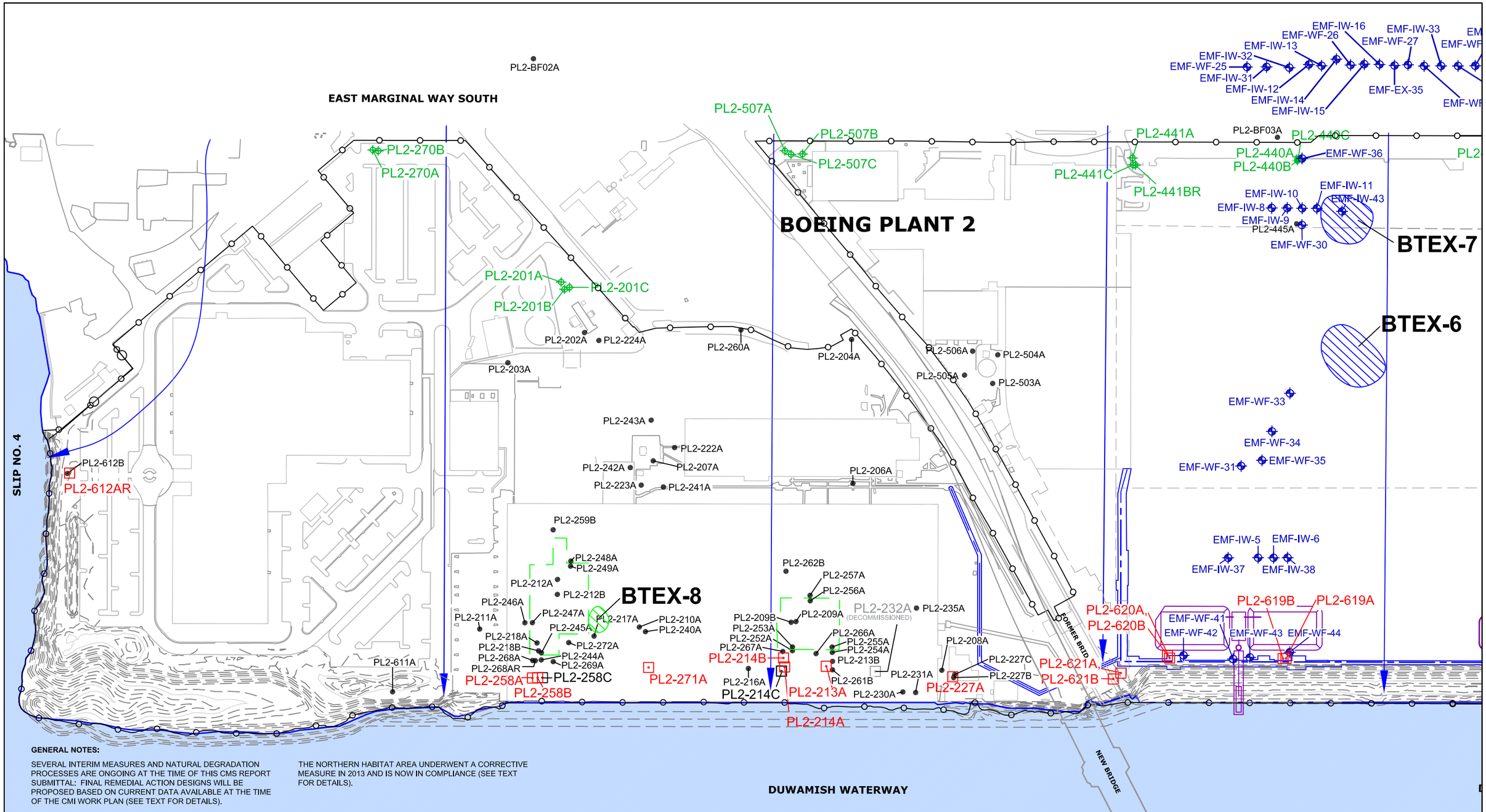
THE SOUTHERN HABITAT AREA AND SOUTHWEST BANK UNDERWENT CORRECTIVE MEASURES IN 2013 AND ARE NOW IN COMPLIANCE (SEE TEXT FOR DETAILS).

PROJECT	BOEING PLANT 2		
PREPARED FOR	THE BOEING COMPANY		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILA, WASHINGTON		
SHEET 1 of 1	DRAWN BY VPB	REVIEWED BY DCK	DATE 10/11/17

ENVIRONMENTAL PARTNERS INC
1180 NW Maple Street, Suite 310
Issaquah, Washington 98027

FIGURE 4-3D

AREAS WITH BTEX OR GRPH CONCENTRATIONS EXCEEDING PROPOSED FMCLs SOUTH PLANT 2



GENERAL NOTES:

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KEY:

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- CURRENT SHORELINE MONITORING WELL
- CURRENT SHORELINE MONITORING WELL NOT PROPOSED FOR FUTURE SHORELINE MONITORING
- UPGRADIENT MONITORING WELL
- PROPERTY BOUNDARY MONITORING WELL
- CURRENT EMF WELL (IW = INJECTION WF = MONITORING)
- OTHER EXISTING WELL
- PROPERTY LINE AS SPECIFIED IN AGREED ORDER
- BUILDINGS
- FORMER BUILDINGS
- DUCT BANK
- SHEETPILE CONTAINMENT STRUCTURE
- STORMWATER SWALES
- A-LEVEL EXCEEDANCES
- B-LEVEL EXCEEDANCES
- C-LEVEL EXCEEDANCES

N

0 50 100 200

SCALE: 1" = 200'

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APPROXIMATE GROUNDWATER FLOW DIRECTION BASED ON RCRA FACILITY GROUNDWATER INVESTIGATION INTERIM REPORT, VOLUME V (WESTON, 1996) AND CONCEPTUAL HYDROLOGIC MODEL DATA GAP INVESTIGATION RESULTS (EPI, 2005)

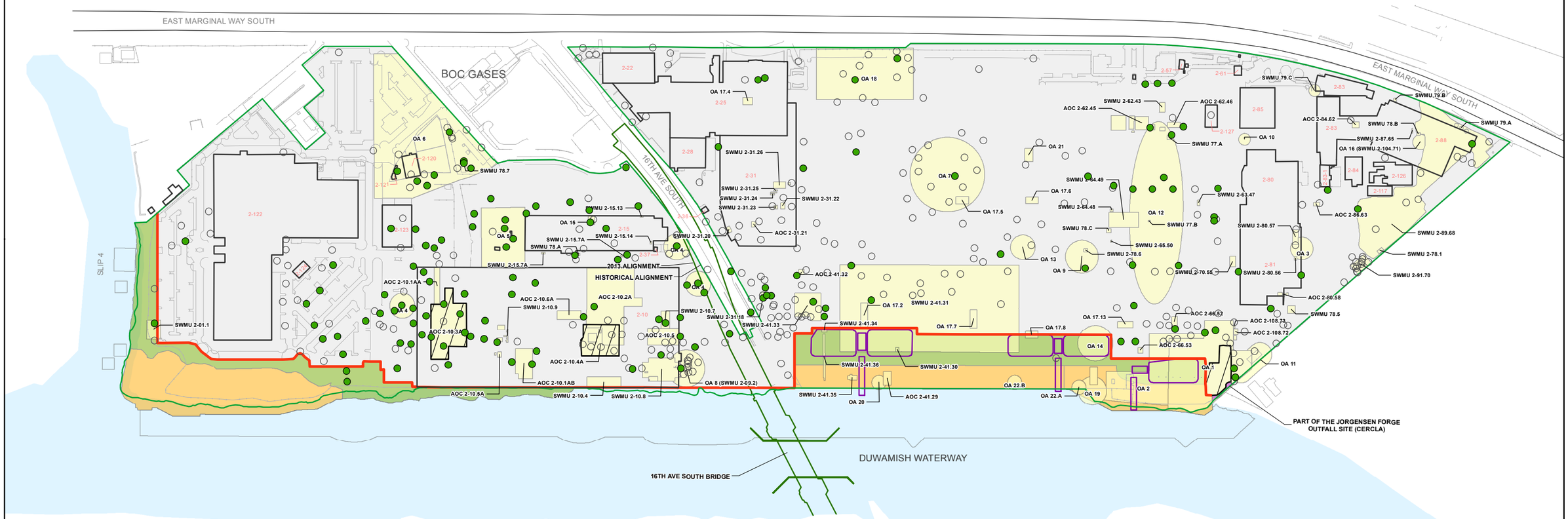
PROJECT	BOEING PLANT 2		
PREPARED FOR	THE BOEING COMPANY		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILA, WASHINGTON		
SHEET 1 of 1	DRAWN BY VPB	REVIEWED BY DCK	DATE 10/11/17

ENVIRONMENTAL PARTNERS INC
1180 NW Maple Street, Suite 310
Issaquah, Washington 98027

FIGURE 4-3E

AREAS WITH BTEX OR GRPH CONCENTRATIONS EXCEEDING PROPOSED FMCLs NORTH PLANT 2

KING COUNTY INTERNATIONAL AIRPORT



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. Purple symbols denote constituent exceeds FMCL, but is not a soil COC based on frequency of exceedance criteria.
4. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **4-4A**
ARSENIC SOIL DATA (0-1 FEET)
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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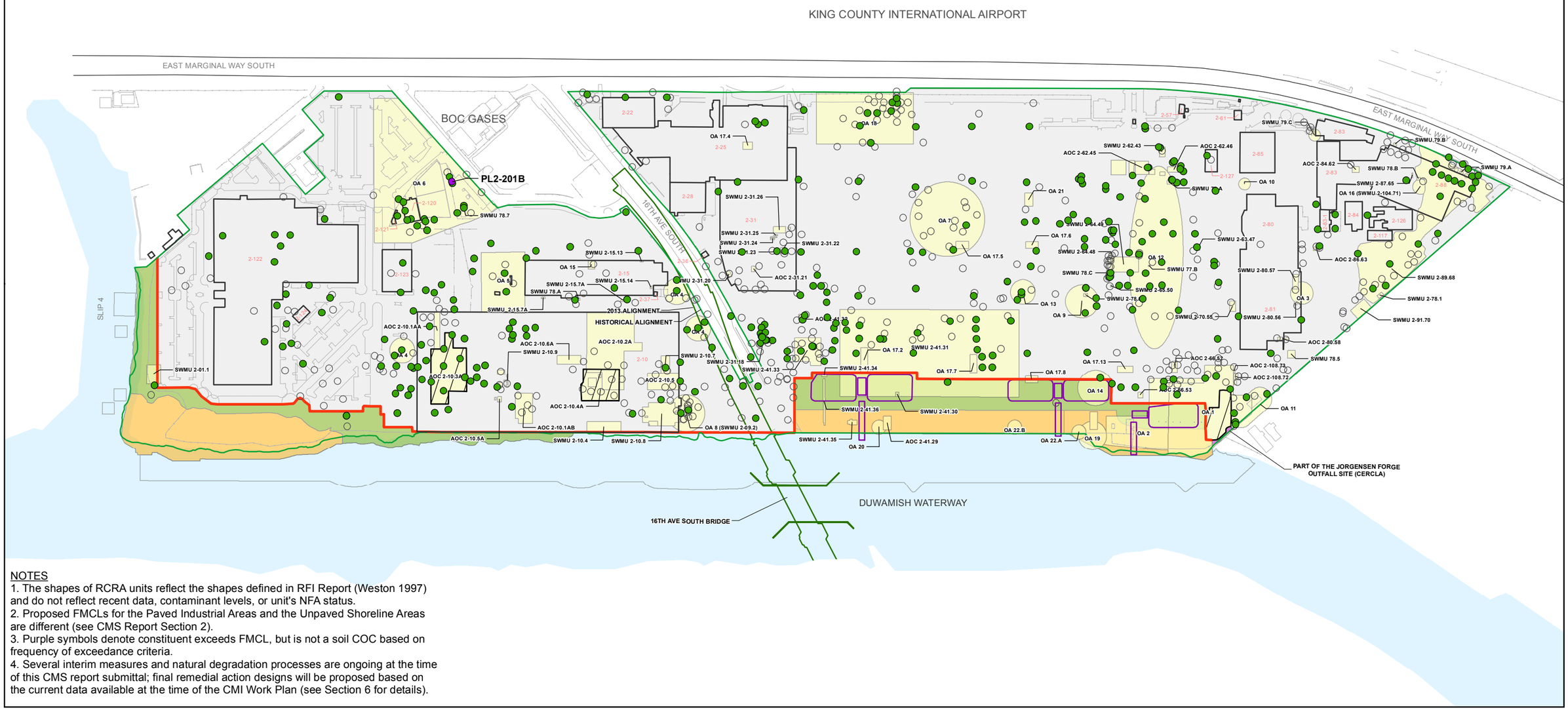
Golder Associates



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. Purple symbols denote constituent exceeds FMCL, but is not a soil COC based on frequency of exceedance criteria.
4. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

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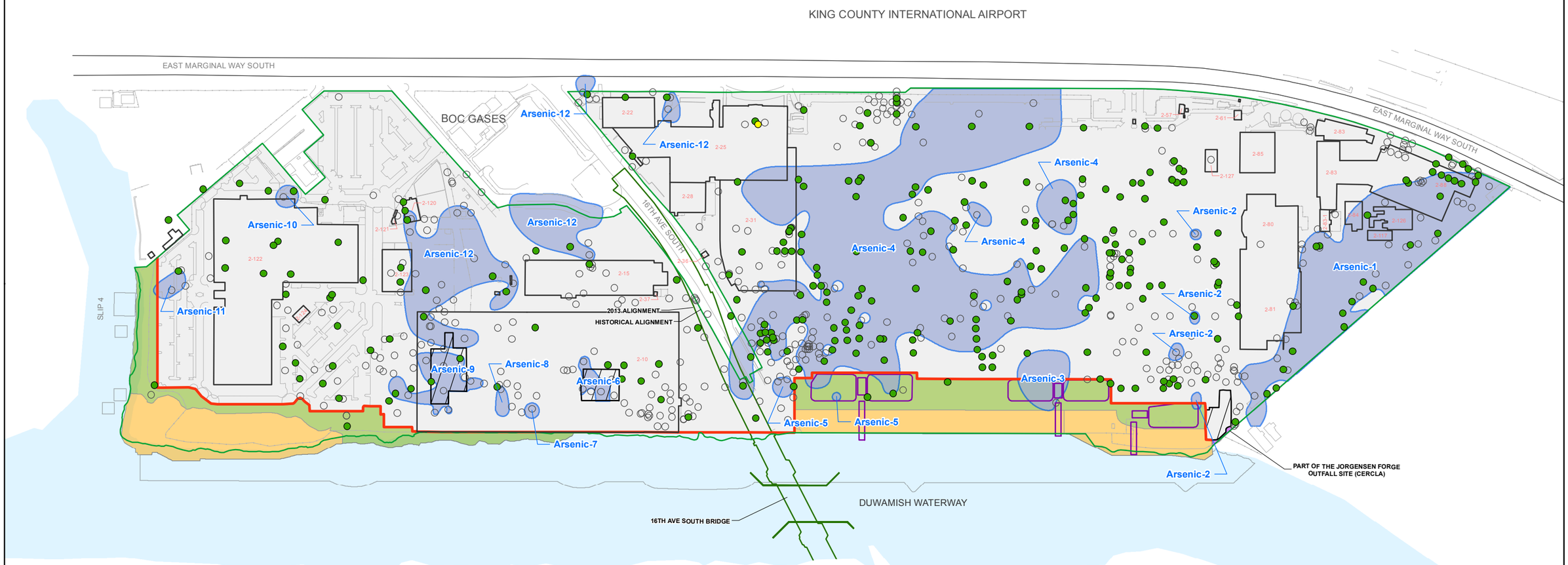
FIGURE **4-4B**
ARSENIC SOIL DATA (1-6 FEET)
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

Path: G:\Boeing\Plant 2\99_PROJECTS\0131646017_CMS_CONSTRUCTION_SUPPORT\100_CMS_SOB_CMI\02_PRODUCTION\MXD\FIGURES\CMS_Report\Rev0\0131646017_100_027_F4_4B_Rev0_Arsenic_1_6.mxd Date: 11/2/2017 User: HJackson

Golder Associates



NOTES
1. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
2. Yellow symbols denote Leaching Screening Levels, see Table 2-6 Leaching Component of the TMCL.
3. Purple symbols denote constituent exceeds FMCL, but is not a soil COC based on frequency of exceedance criteria.
4. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- A-Level Groundwater Exceedance Area

Arsenic-1 Exceedance Area Identifier

- Stormwater Swale

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

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FIGURE **4-4C**

SOIL DATA (6-11 FEET) AND A-LEVEL GROUNDWATER EXCEEDANCE AREAS CONCENTRATIONS COMPARED TO CLEANUP LEVELS FOR ARSENIC

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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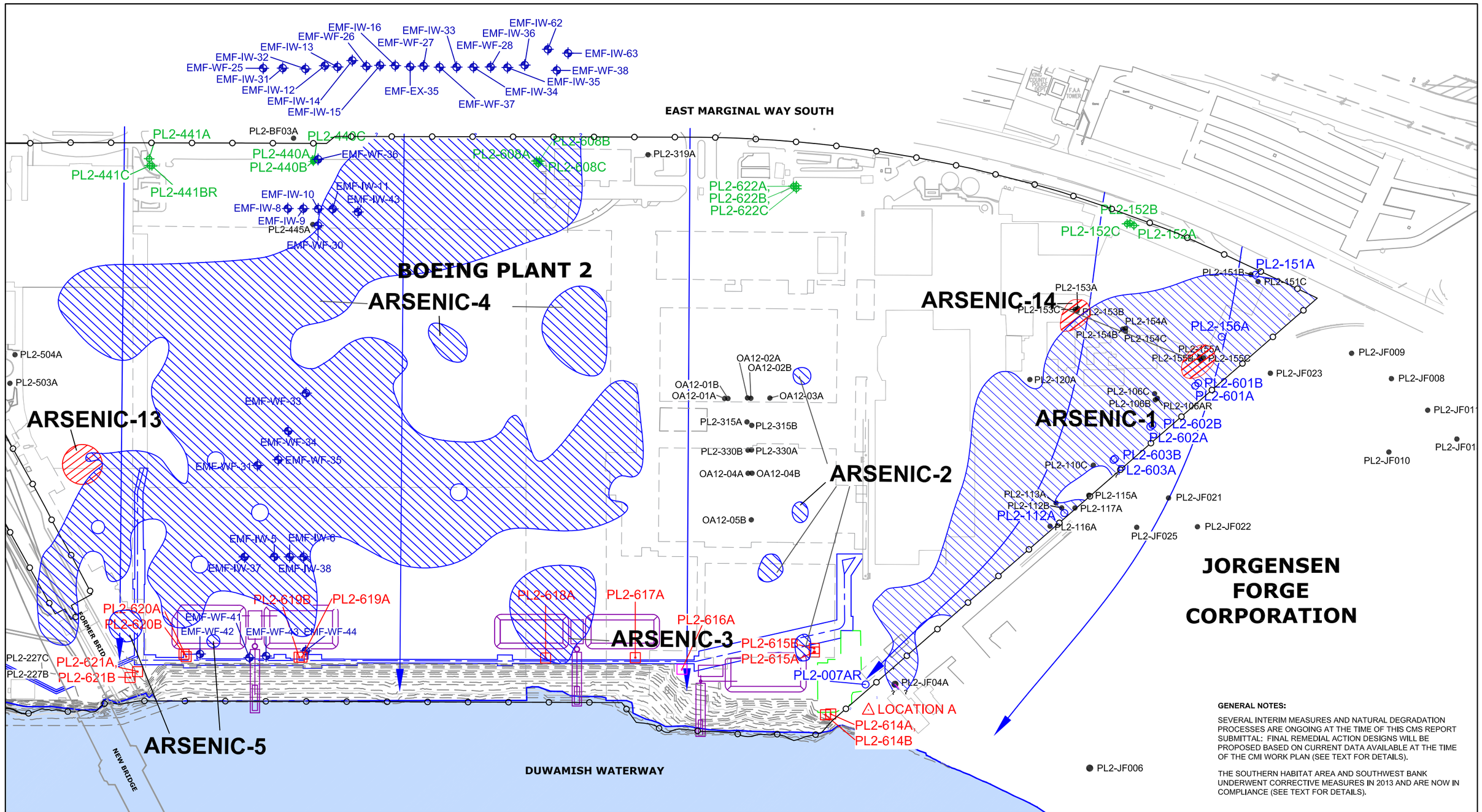
Golder Associates



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THE SOUTHERN HABITAT AREA AND SOUTHWEST BANK UNDERWENT CORRECTIVE MEASURES IN 2013 AND ARE NOW IN COMPLIANCE (SEE TEXT FOR DETAILS).

KEY:

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- CURRENT SHORELINE MONITORING WELL
- CURRENT SHORELINE MONITORING WELL NOT PROPOSED FOR FUTURE SHORELINE MONITORING
- UPGRADIENT MONITORING WELL
- PROPERTY BOUNDARY MONITORING WELL
- CURRENT EMF WELL (IW = INJECTION WF = MONITORING)
- OTHER EXISTING WELL
- PROPERTY LINE AS SPECIFIED IN AGREED ORDER
- BUILDINGS
- FORMER BUILDINGS
- DUCT BANK
- SHEETPILE CONTAINMENT STRUCTURE
- STORMWATER SWALES
- A-LEVEL EXCEEDANCES
- B-LEVEL EXCEEDANCES
- C-LEVEL EXCEEDANCES

N

0 50 100 200

SCALE: 1" = 200'

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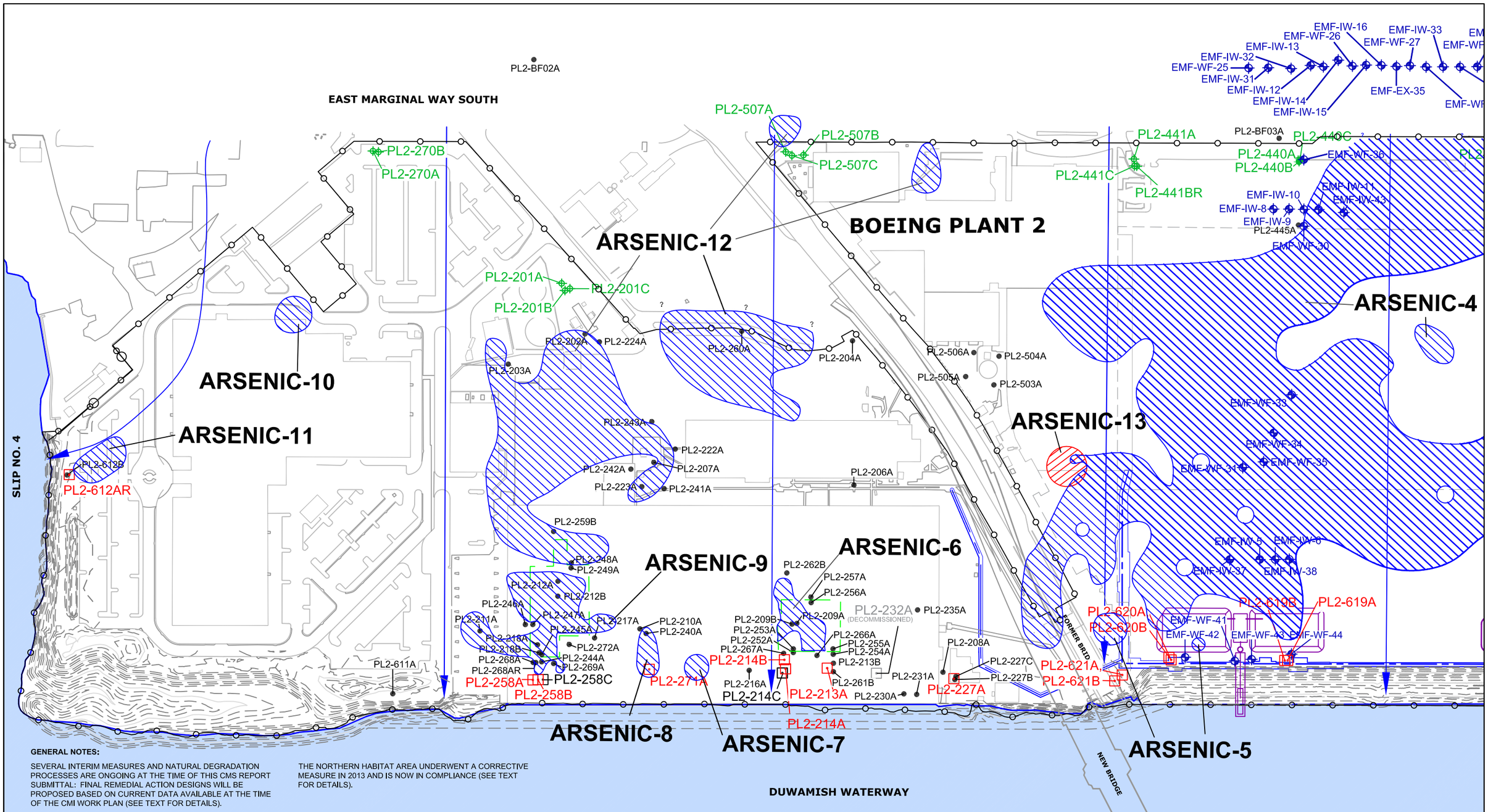
APPROXIMATE GROUNDWATER FLOW DIRECTION BASED ON RCRA FACILITY GROUNDWATER INVESTIGATION INTERIM REPORT, VOLUME V (WESTON, 1996) AND CONCEPTUAL HYDROLOGIC MODEL DATA GAP INVESTIGATION RESULTS (EPI, 2005)

PROJECT	BOEING PLANT 2		
PREPARED FOR	THE BOEING COMPANY		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILA, WASHINGTON		
SHEET 1 of 1	DRAWN BY VPB	REVIEWED BY DCK	DATE 10/12/17

ENVIRONMENTAL PARTNERS INC
1180 NW Maple Street, Suite 310
Issaquah, Washington 98027

FIGURE 4-4D

AREAS WITH ARSENIC CONCENTRATIONS EXCEEDING THE PROPOSED FMCLs SOUTH PLANT 2



GENERAL NOTES:

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THE NORTHERN HABITAT AREA UNDERWENT A CORRECTIVE MEASURE IN 2013 AND IS NOW IN COMPLIANCE (SEE TEXT FOR DETAILS).

KEY:

- PROPOSED NEW SHORELINE MONITORING WELL
- CURRENT SHORELINE MONITORING WELL
- CURRENT SHORELINE MONITORING WELL NOT PROPOSED FOR FUTURE SHORELINE MONITORING
- UPGRADIENT MONITORING WELL
- PROPERTY BOUNDARY MONITORING WELL
- CURRENT EMF WELL (IW = INJECTION WF = MONITORING)
- OTHER EXISTING WELL
- PROPERTY LINE AS SPECIFIED IN AGREED ORDER
- BUILDINGS
- FORMER BUILDINGS
- DUCT BANK
- SHEETPILE CONTAINMENT STRUCTURE
- STORMWATER SWALES
- A-LEVEL EXCEEDANCES
- B-LEVEL EXCEEDANCES
- C-LEVEL EXCEEDANCES

N

0 50 100 200

SCALE: 1" = 200'

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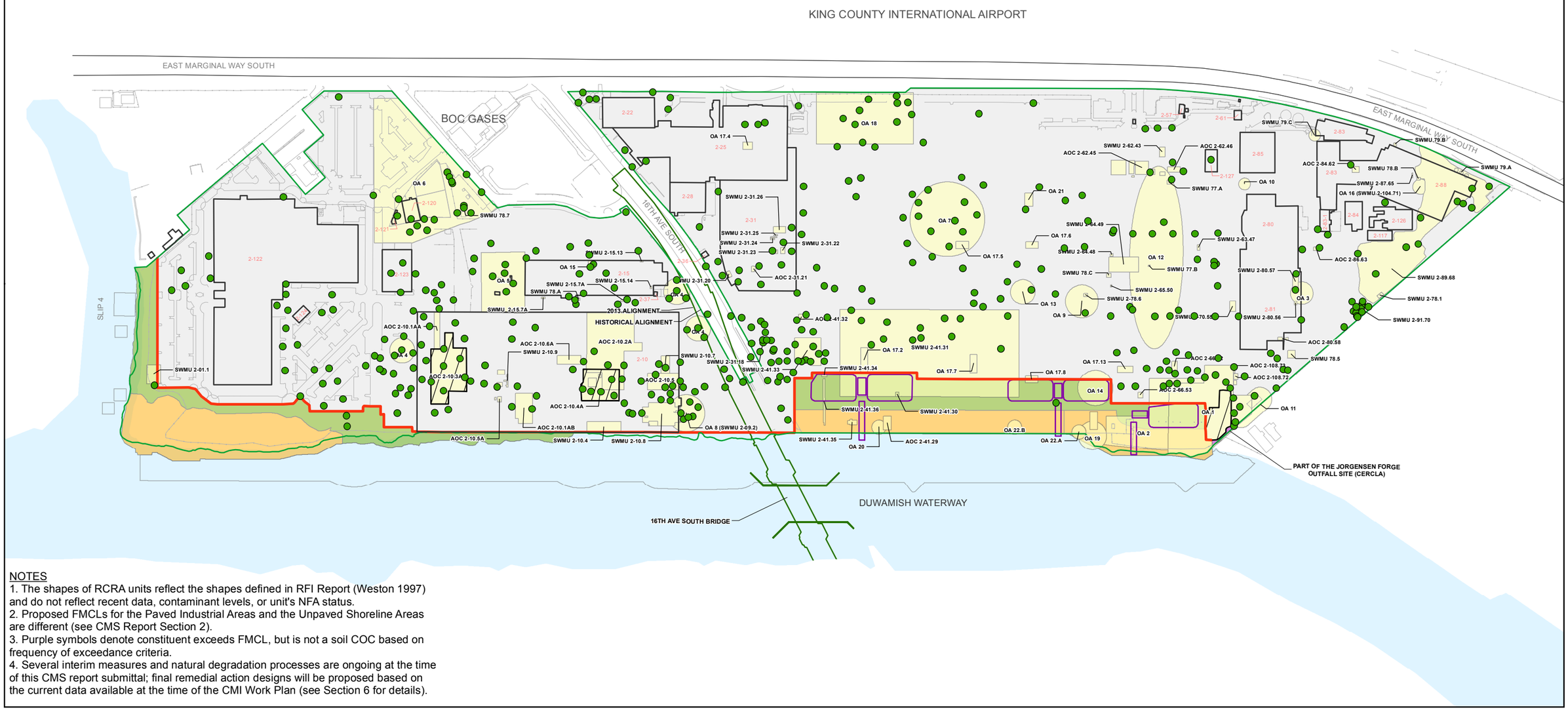
APPROXIMATE GROUNDWATER FLOW DIRECTION BASED ON RCRA FACILITY GROUNDWATER INVESTIGATION INTERIM REPORT, VOLUME V (WESTON, 1996) AND CONCEPTUAL HYDROLOGIC MODEL DATA GAP INVESTIGATION RESULTS (EPI, 2005)

PROJECT	BOEING PLANT 2		
PREPARED FOR	THE BOEING COMPANY		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILA, WASHINGTON		
SHEET 1 of 1	DRAWN BY VPB	REVIEWED BY DCK	DATE 10/12/17

ENVIRONMENTAL PARTNERS INC
1180 NW Maple Street, Suite 310
Issaquah, Washington 98027

FIGURE 4-4E

AREAS WITH ARSENIC CONCENTRATIONS EXCEEDING THE PROPOSED FMCLs NORTH PLANT 2



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. Purple symbols denote constituent exceeds FMCL, but is not a soil COC based on frequency of exceedance criteria.
4. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **4-5A**
COPPER OR ZINC SOIL DATA (0-1 FEET)
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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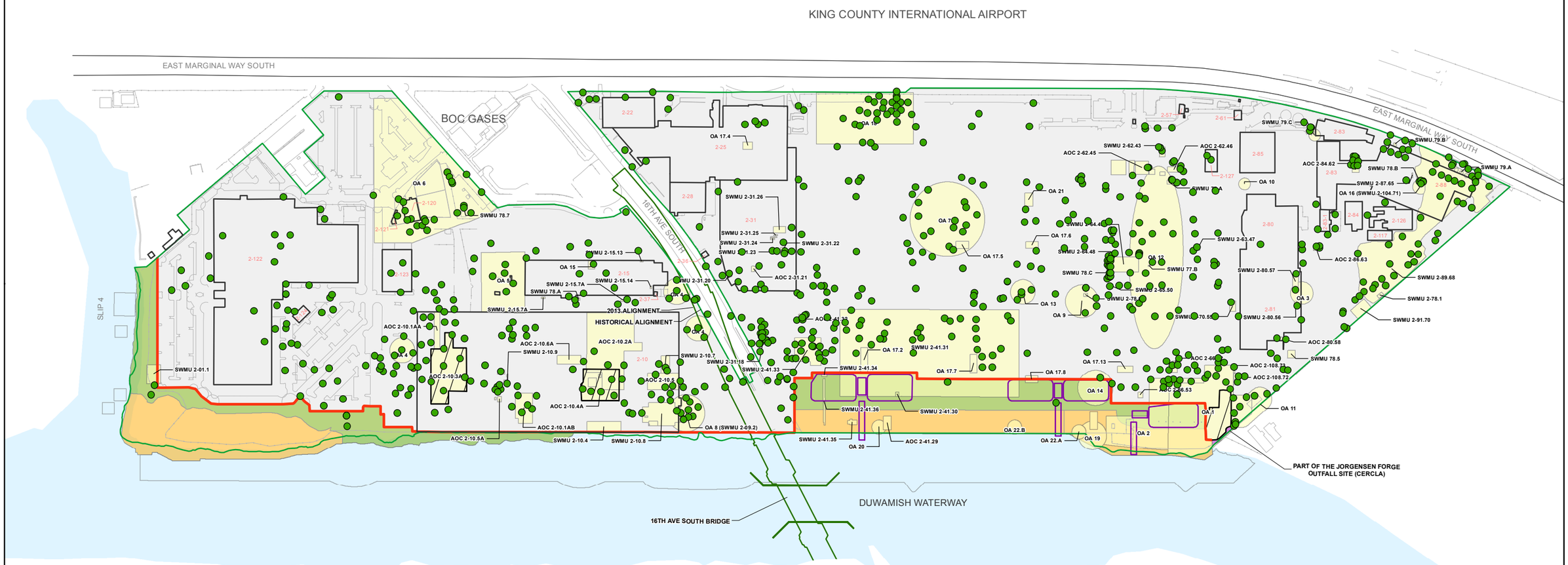
Golder Associates



NOTES
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4. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

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FIGURE **4-5B**
COPPER OR ZINC SOIL DATA (1-6 FEET)
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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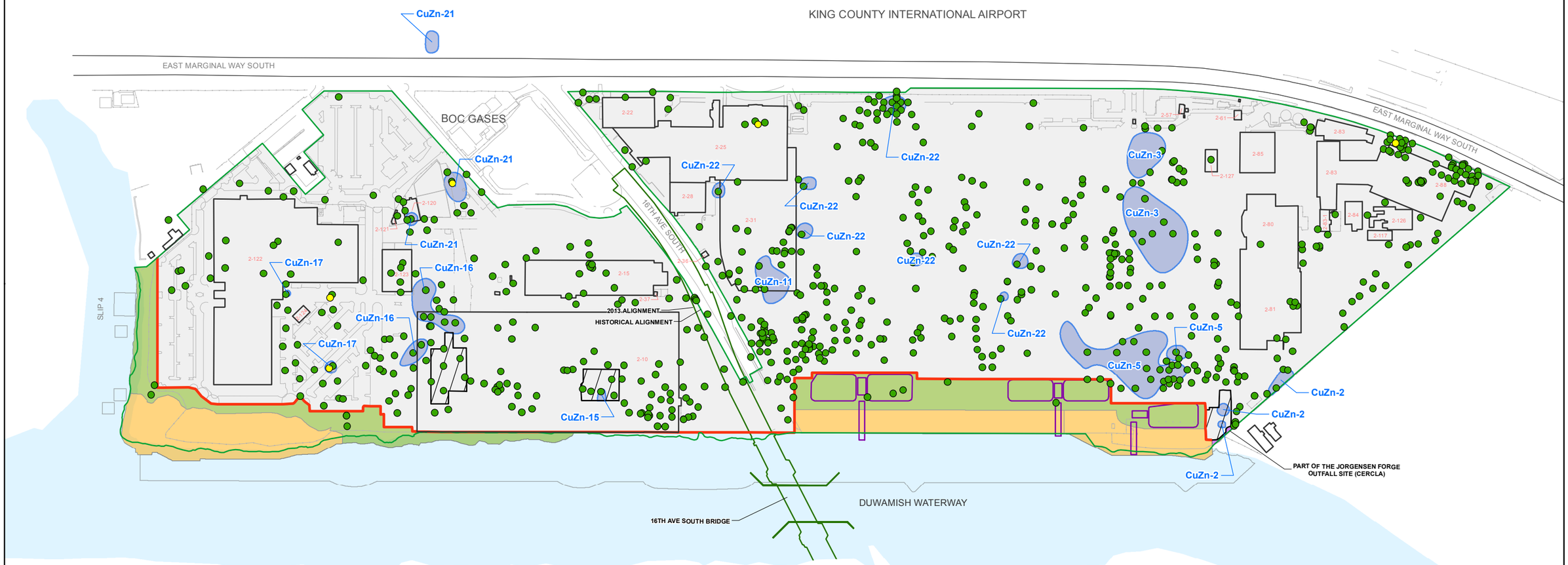
Golder Associates



NOTES
1. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
2. Yellow symbols denote Leaching Screening Levels, see Table 2-6 Leaching Component of the TMCL.
3. Purple symbols denote constituent exceeds FMCL, but is not a soil COC based on frequency of exceedance criteria.
4. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- A-Level Groundwater Exceedance Area
- **CuZn-1** Exceedance Area Identifier

- Stormwater Swale

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

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FIGURE **4-5C**

SOIL DATA (6-11 FEET) AND A-LEVEL GROUNDWATER EXCEEDANCE AREAS CONCENTRATIONS COMPARED TO CLEANUP LEVELS FOR COPPER OR ZINC

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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Golder Associates

EAST MARGINAL WAY SOUTH

BOEING PLANT 2

JORGENSEN FORGE CORPORATION

DUWAMISH WATERWAY

CuZn-1
CuZn-2
CuZn-3
CuZn-4
CuZn-5
CuZn-6
CuZn-7
CuZn-8
CuZn-9
CuZn-10
CuZn-11
CuZn-12
CuZn-22
CuZn-23

EMF-IW-16, EMF-WF-26, EMF-IW-13, EMF-IW-32, EMF-WF-25, EMF-IW-31, EMF-IW-12, EMF-IW-14, EMF-IW-15, EMF-IW-33, EMF-WF-27, EMF-EX-35, EMF-WF-28, EMF-WF-37, EMF-IW-36, EMF-IW-34, EMF-IW-62, EMF-IW-63, EMF-WF-38, EMF-IW-35

PL2-441A, PL2-441C, PL2-441BR, PL2-BF03A, PL2-440C, PL2-440A, PL2-440B, EMF-WF-36, PL2-608A, PL2-608B, PL2-608C, PL2-319A, EMF-IW-10, EMF-IW-11, EMF-IW-8, EMF-IW-43, EMF-IW-9, PL2-445A, EMF-WF-30, PL2-622A, PL2-622B, PL2-622C, PL2-152B, PL2-152C, PL2-152A, PL2-151A, PL2-151B, PL2-151C, PL2-153A, PL2-153C, PL2-153B, PL2-154A, PL2-154B, PL2-154C, PL2-156A, PL2-155A, PL2-155B, PL2-155C, PL2-JF009, PL2-JF023, PL2-JF008, PL2-504A, PL2-503A, PL2-120A, PL2-106C, PL2-106B, PL2-106AR, PL2-601B, PL2-601A, PL2-602B, PL2-602A, PL2-603B, PL2-603A, PL2-JF011, PL2-JF010, PL2-JF015, EMF-WF-33, OA12-02A, OA12-02B, OA12-01B, OA12-01A, OA12-03A, PL2-315A, PL2-315B, PL2-330B, PL2-330A, OA12-04A, OA12-04B, EMF-WF-34, EMF-WF-35, EMF-WF-31, PL2-110C, PL2-113A, PL2-112B, PL2-115A, PL2-117A, PL2-112A, PL2-116A, PL2-JF021, PL2-JF025, PL2-JF022, OA12-05B, EMF-IW-5, EMF-IW-6, EMF-IW-37, EMF-IW-38, PL2-619B, PL2-619A, PL2-620A, PL2-620B, EMF-WF-41, EMF-WF-42, EMF-WF-43, EMF-WF-44, PL2-618A, PL2-617A, PL2-616A, PL2-615B, PL2-615A, PL2-007AR, PL2-JF04A, PL2-227C, PL2-227B, PL2-621A, PL2-621B, LOCATION A, PL2-614A, PL2-614B, PL2-JF006

FORMER BRID

NEW BRIDGE

13

GENERAL NOTES:

SEVERAL INTERIM MEASURES AND NATURAL DEGRADATION PROCESSES ARE ONGOING AT THE TIME OF THIS CMS REPORT SUBMITTAL: FINAL REMEDIAL ACTION DESIGNS WILL BE PROPOSED BASED ON CURRENT DATA AVAILABLE AT THE TIME OF THE CMI WORK PLAN (SEE TEXT FOR DETAILS).

THE SOUTHERN HABITAT AREA AND SOUTHWEST BANK UNDERWENT CORRECTIVE MEASURES IN 2013 AND ARE NOW IN COMPLIANCE (SEE TEXT FOR DETAILS).

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- BUILDINGS
- FORMER BUILDINGS
- DUCT BANK
- SHEETPILE CONTAINMENT STRUCTURE
- STORMWATER SWALES
- A-LEVEL EXCEEDANCES
- B-LEVEL EXCEEDANCES
- C-LEVEL EXCEEDANCES

N

0 50 100 200

SCALE: 1" = 200'

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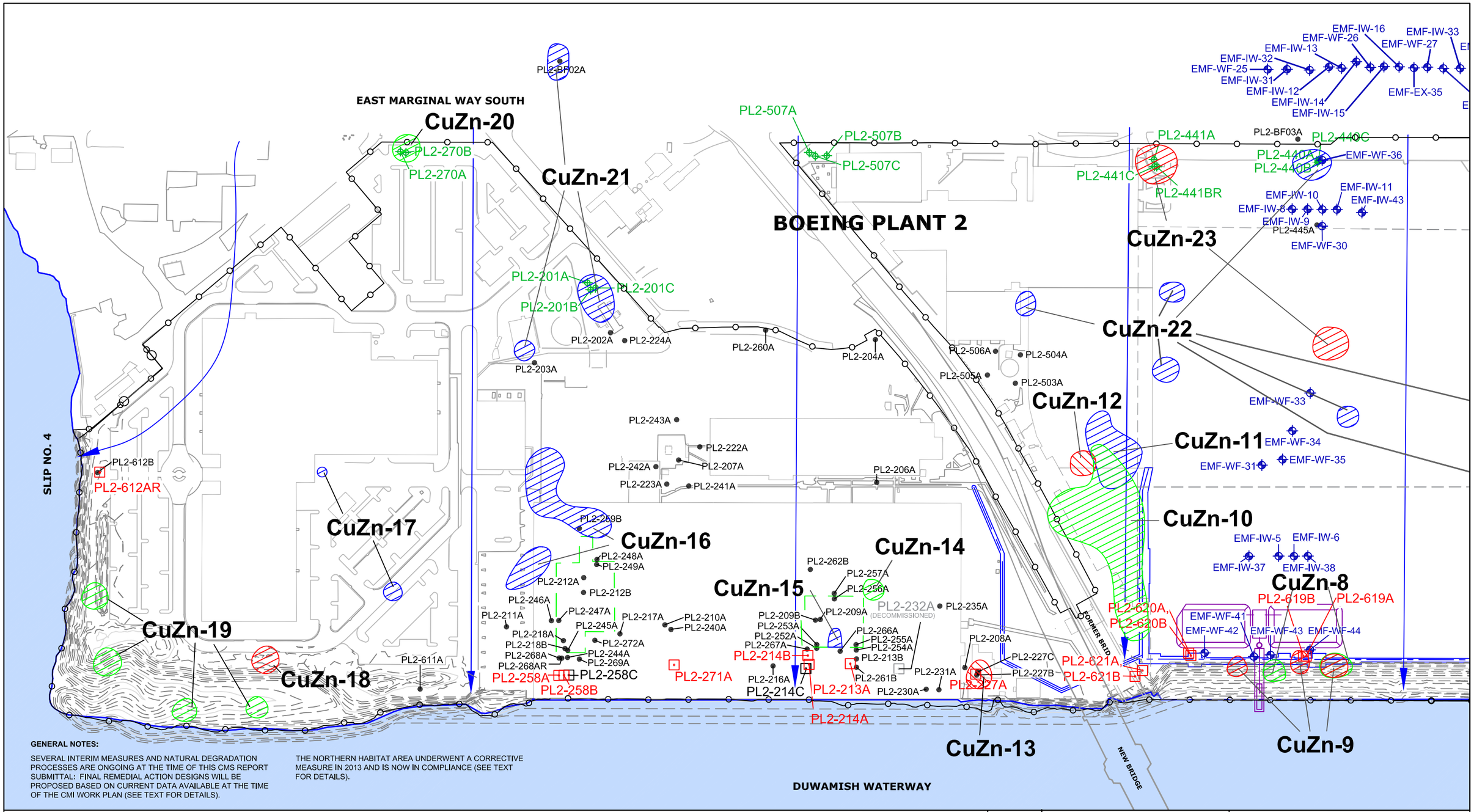
APPROXIMATE GROUNDWATER FLOW DIRECTION BASED ON RCRA FACILITY GROUNDWATER INVESTIGATION INTERIM REPORT, VOLUME V (WESTON, 1996) AND CONCEPTUAL HYDROLOGIC MODEL DATA GAP INVESTIGATION RESULTS (EPI, 2005)

PROJECT	BOEING PLANT 2			
PREPARED FOR	THE BOEING COMPANY			
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILA, WASHINGTON			
SHEET	DRAWN BY	REVIEWED BY	DATE	
1 of 1	VPB	DCK	10/11/17	

ENVIRONMENTAL PARTNERS INC
1180 NW Maple Street, Suite 310
Issaquah, Washington 98027

FIGURE 4-5D

AREAS WITH COPPER OR ZINC CONCENTRATIONS EXCEEDING PROPOSED FMCLs SOUTH PLANT 2



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KEY:

N

0 50 100 200

SCALE: 1" = 200'

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- CURRENT SHORELINE MONITORING WELL NOT PROPOSED FOR FUTURE SHORELINE MONITORING
- UPGRADIENT MONITORING WELL
- PROPERTY BOUNDARY MONITORING WELL
- CURRENT EMF WELL (IW = INJECTION WF = MONITORING)
- OTHER EXISTING WELL
- PROPERTY LINE AS SPECIFIED IN AGREED ORDER
- BUILDINGS
- FORMER BUILDINGS
- DUCT BANK
- SHEETPILE CONTAINMENT STRUCTURE
- STORMWATER SWALES
- A-LEVEL EXCEEDANCES
- B-LEVEL EXCEEDANCES
- C-LEVEL EXCEEDANCES

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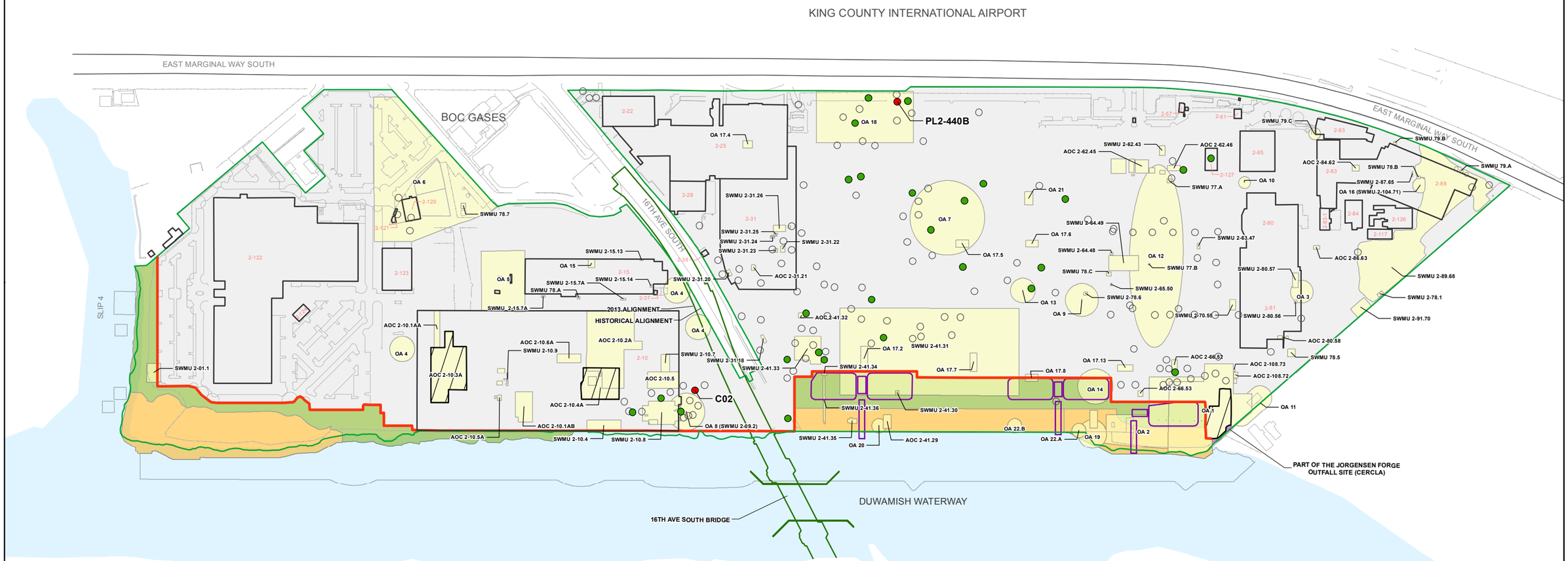
APPROXIMATE GROUNDWATER FLOW DIRECTION BASED ON RCRA FACILITY GROUNDWATER INVESTIGATION INTERIM REPORT, VOLUME V (WESTON, 1996) AND CONCEPTUAL HYDROLOGIC MODEL DATA GAP INVESTIGATION RESULTS (EPI, 2005)

PROJECT	BOEING PLANT 2		
PREPARED FOR	THE BOEING COMPANY		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILA, WASHINGTON		
SHEET 1 of 1	DRAWN BY VPB	REVIEWED BY DCK	DATE 10/11/17

ENVIRONMENTAL PARTNERS INC
1180 NW Maple Street, Suite 310
Issaquah, Washington 98027

FIGURE 4-5E

AREAS WITH COPPER OR ZINC CONCENTRATIONS EXCEEDING FMCLs
NORTH PLANT 2



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
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LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

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FIGURE **4-6A**
CYANIDE SOIL DATA (0-1 FEET)
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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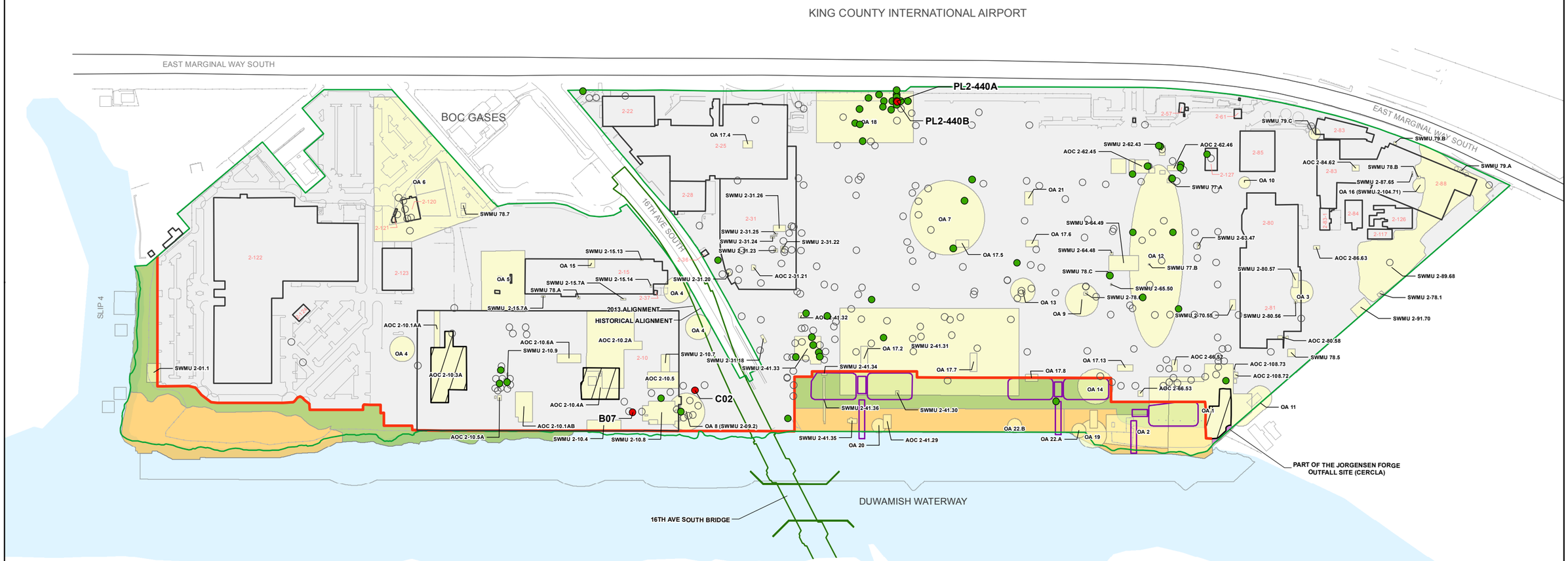
Golder Associates



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2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
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LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
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- Detected Above Proposed Industrial FMCL
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- Paved Industrial/Unpaved Shoreline Separation Line
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- Bridge Alignment
- Sheetpile
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Risk Management Area
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0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

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FIGURE **4-6B**
CYANIDE SOIL DATA (1-6 FEET)
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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NOTES
1. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
2. Yellow symbols denote Leaching Screening Levels, see Table 2-6 Leaching Component of the TMCL.
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LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- A-Level Groundwater Exceedance Area
- **Cyanide-1** Exceedance Area Identifier
- Stormwater Swale

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

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FIGURE **4-6C**

SOIL DATA (6-11 FEET) AND A-LEVEL GROUNDWATER EXCEEDANCE AREAS CONCENTRATIONS COMPARED TO CLEANUP LEVELS FOR CYANIDE

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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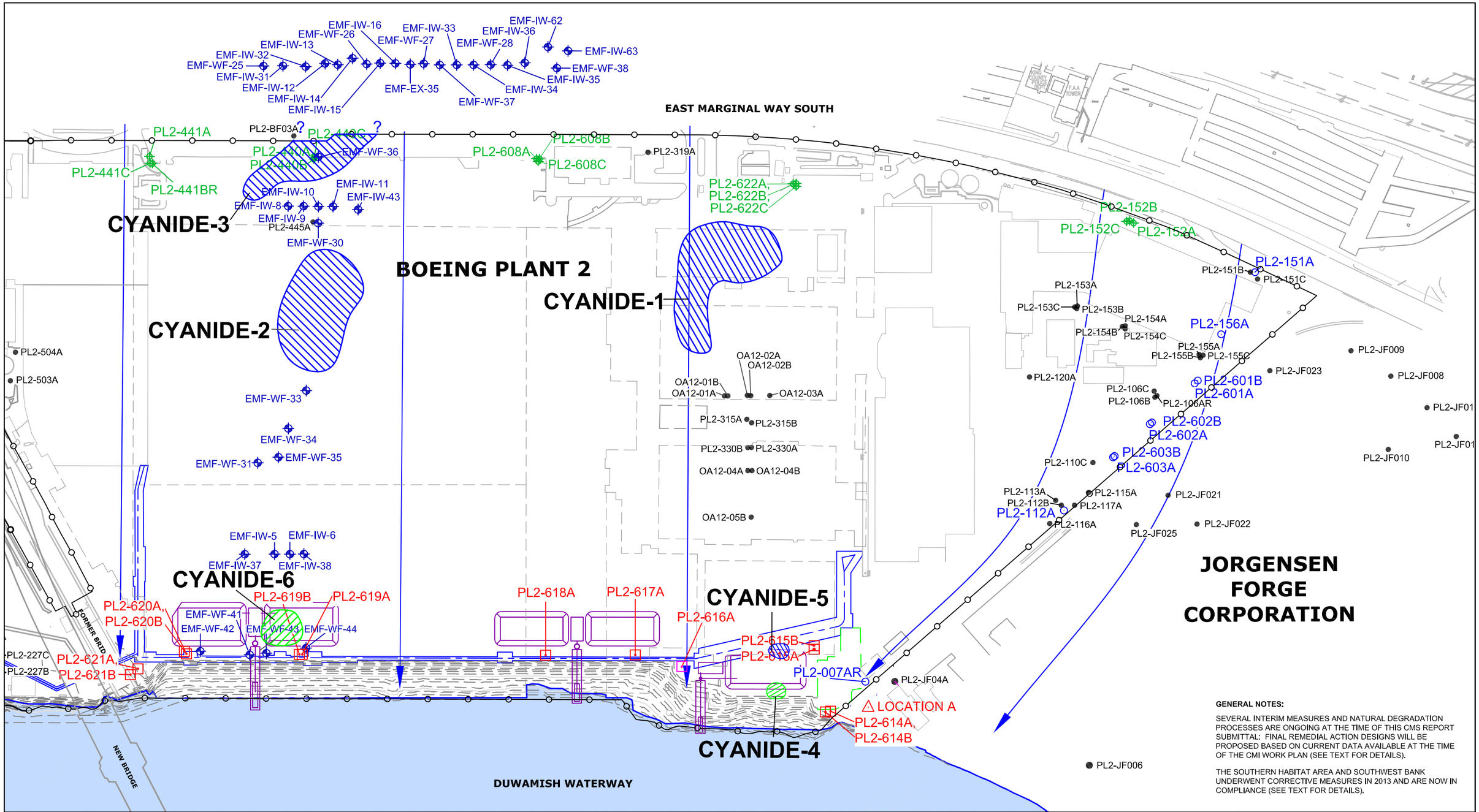
Golder Associates



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KEY:

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- CURRENT SHORELINE MONITORING WELL NOT PROPOSED FOR FUTURE SHORELINE MONITORING
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- A-LEVEL EXCEEDANCES
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N

0 50 100 200

SCALE: 1" = 200'

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APPROXIMATE GROUNDWATER FLOW DIRECTION BASED ON RCRA FACILITY GROUNDWATER INVESTIGATION INTERIM REPORT, VOLUME V (WESTON, 1996) AND CONCEPTUAL HYDROLOGIC MODEL DATA GAP INVESTIGATION RESULTS (EPI, 2005)

PROJECT	BOEING PLANT 2		
PREPARED FOR	THE BOEING COMPANY		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILA, WASHINGTON		
SHEET 1 of 1	DRAWN BY VPB	REVIEWED BY DCK	DATE 10/11/17

ENVIRONMENTAL PARTNERS INC
1180 NW Maple Street, Suite 310
Issaquah, Washington 98027

FIGURE 4-6D

AREAS WITH CYANIDE CONCENTRATIONS EXCEEDING THE PROPOSED FMCL SOUTH PLANT 2

EAST MARGINAL WAY SOUTH

BOEING PLANT 2

CYANIDE-3

CYANIDE-2

CYANIDE-6

SLIP NO. 4

DUWAMISH WATERWAY

FORMER BRIDGE

NEW BRIDGE

PL2-BF02A
PL2-270B
PL2-270A
PL2-507A
PL2-507B
PL2-507C
PL2-441A
PL2-441C
PL2-441BR
PL2-BF03A
PL2-440C
PL2-440A
PL2-440B
EMF-WF-36
EMF-IW-16
EMF-WF-26
EMF-IW-33
EMF-WF-27
EMF-IW-13
EMF-IW-32
EMF-WF-25
EMF-IW-31
EMF-IW-12
EMF-IW-14
EMF-IW-15
EMF-EX-35
EMF-IW-10
EMF-IW-11
EMF-IW-43
EMF-IW-8
EMF-IW-9
PL2-445A
EMF-WF-30
PL2-201A
PL2-201C
PL2-201B
PL2-202A
PL2-224A
PL2-260A
PL2-204A
PL2-203A
PL2-506A
PL2-504A
PL2-505A
PL2-503A
EMF-WF-33
PL2-243A
PL2-222A
PL2-242A
PL2-207A
PL2-223A
PL2-241A
PL2-206A
EMF-WF-34
EMF-WF-31
EMF-WF-35
PL2-612B
PL2-612AR
PL2-259B
PL2-248A
PL2-249A
PL2-212A
PL2-212B
PL2-246A
PL2-211A
PL2-247A
PL2-217A
PL2-210A
PL2-240A
PL2-245A
PL2-218A
PL2-218B
PL2-272A
PL2-268A
PL2-244A
PL2-268AR
PL2-269A
PL2-611A
PL2-258A
PL2-258C
PL2-258B
PL2-271A
PL2-262B
PL2-257A
PL2-256A
PL2-232A (DECOMMISSIONED)
PL2-235A
PL2-209B
PL2-209A
PL2-253A
PL2-252A
PL2-266A
PL2-255A
PL2-267A
PL2-254A
PL2-214B
PL2-213B
PL2-208A
PL2-227C
PL2-216A
PL2-261B
PL2-231A
PL2-227B
PL2-214C
PL2-213A
PL2-230A
PL2-227A
PL2-214A
PL2-620A
PL2-620B
PL2-621A
PL2-621B
EMF-IW-5
EMF-IW-6
EMF-IW-37
EMF-IW-38
PL2-619B
PL2-619A
EMF-WF-41
EMF-WF-42
EMF-WF-43
EMF-WF-44

GENERAL NOTES:

SEVERAL INTERIM MEASURES AND NATURAL DEGRADATION PROCESSES ARE ONGOING AT THE TIME OF THIS CMS REPORT SUBMITTAL: FINAL REMEDIAL ACTION DESIGNS WILL BE PROPOSED BASED ON CURRENT DATA AVAILABLE AT THE TIME OF THE CMI WORK PLAN (SEE TEXT FOR DETAILS).

THE NORTHERN HABITAT AREA UNDERWENT A CORRECTIVE MEASURE IN 2013 AND IS NOW IN COMPLIANCE (SEE TEXT FOR DETAILS).

KEY:

N

0 50 100 200

SCALE: 1" = 200'

- PROPOSED NEW SHORELINE MONITORING WELL
- CURRENT SHORELINE MONITORING WELL
- CURRENT SHORELINE MONITORING WELL NOT PROPOSED FOR FUTURE SHORELINE MONITORING
- UPGRADIENT MONITORING WELL
- PROPERTY BOUNDARY MONITORING WELL
- CURRENT EMF WELL (IW = INJECTION WF = MONITORING)
- OTHER EXISTING WELL
- PROPERTY LINE AS SPECIFIED IN AGREED ORDER
- BUILDINGS
- FORMER BUILDINGS
- DUCT BANK
- SHEETPILE CONTAINMENT STRUCTURE
- STORMWATER SWALES
- A-LEVEL EXCEEDANCES
- B-LEVEL EXCEEDANCES
- C-LEVEL EXCEEDANCES

THIS FIGURE WAS ORIGINALLY PRODUCED IN COLOR. REPRODUCTION IN BLACK AND WHITE MAY RESULT IN LOSS OF INFORMATION.

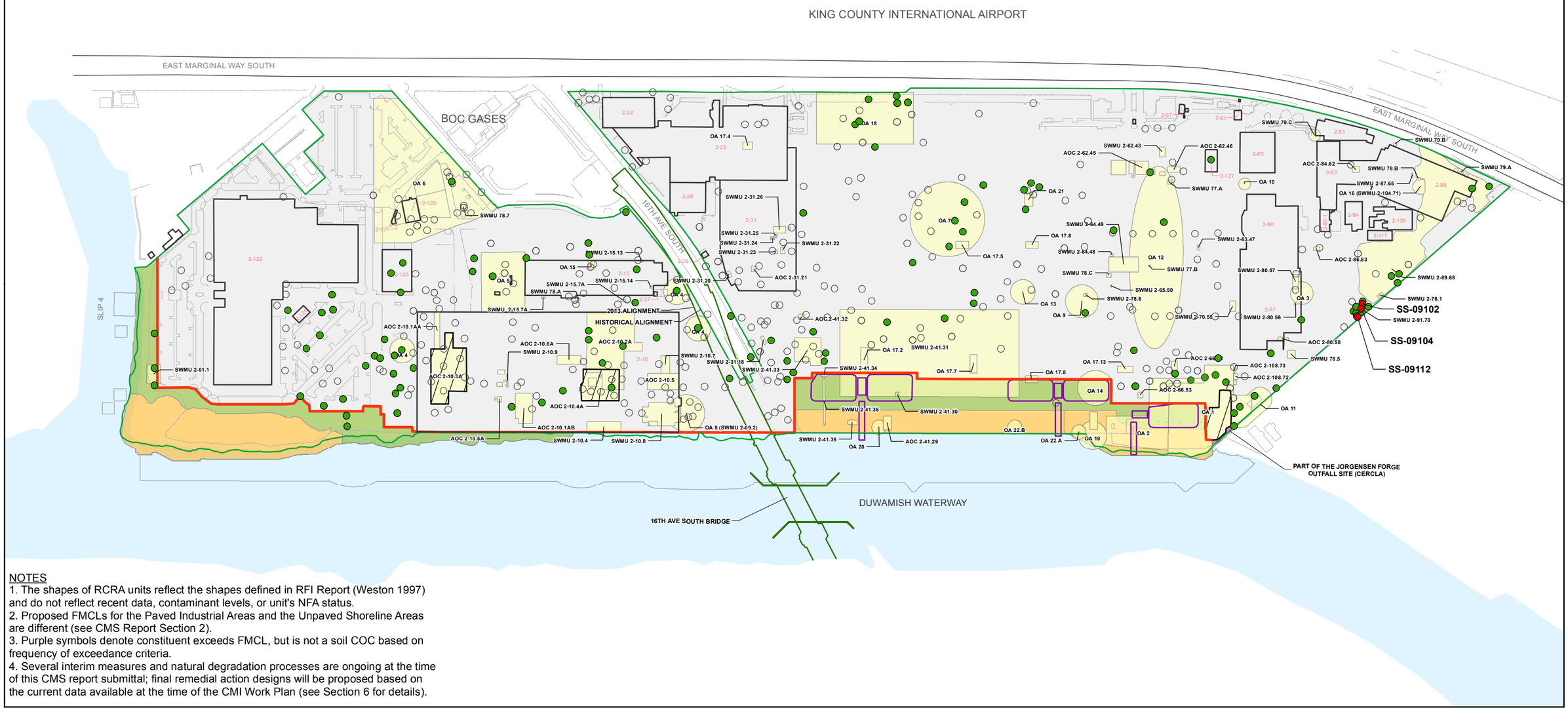
APPROXIMATE GROUNDWATER FLOW DIRECTION BASED ON RCRA FACILITY GROUNDWATER INVESTIGATION INTERIM REPORT, VOLUME V (WESTON, 1996) AND CONCEPTUAL HYDROLOGIC MODEL DATA GAP INVESTIGATION RESULTS (EPI, 2005)

PROJECT	BOEING PLANT 2		
PREPARED FOR	THE BOEING COMPANY		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILA, WASHINGTON		
SHEET 1 of 1	DRAWN BY VPB	REVIEWED BY DCK	DATE 10/6/17

ENVIRONMENTAL PARTNERS INC
1180 NW Maple Street, Suite 310
Issaquah, Washington 98027

FIGURE 4-6E

AREAS WITH CYANIDE CONCENTRATIONS EXCEEDING THE PROPOSED FMCL NORTH PLANT 2



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. Purple symbols denote constituent exceeds FMCL, but is not a soil COC based on frequency of exceedance criteria.
4. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **4-7A**
DRPH, MoRPH, OR
NAPHTHALENE SOIL DATA (0-1 FEET)
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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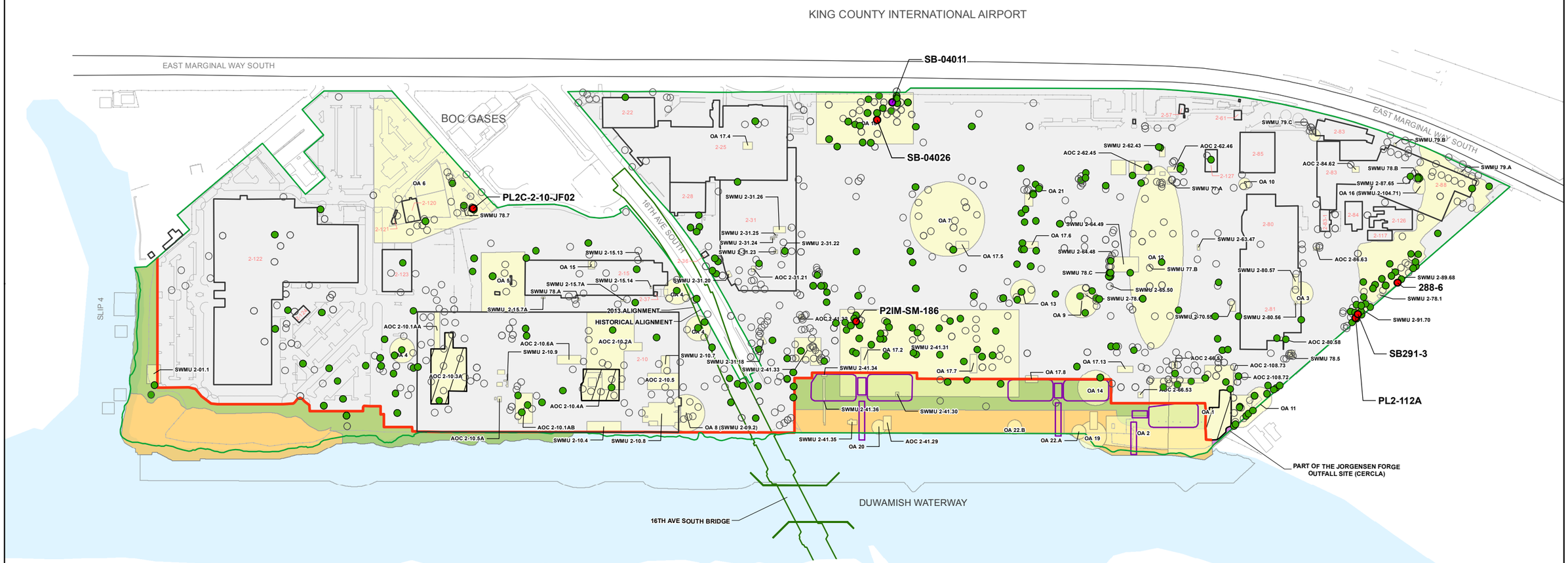
Golder Associates



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
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LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

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FIGURE **4-7B**
DRPH, MoRPH, OR
NAPHTHALENE SOIL DATA (1-6 FEET)
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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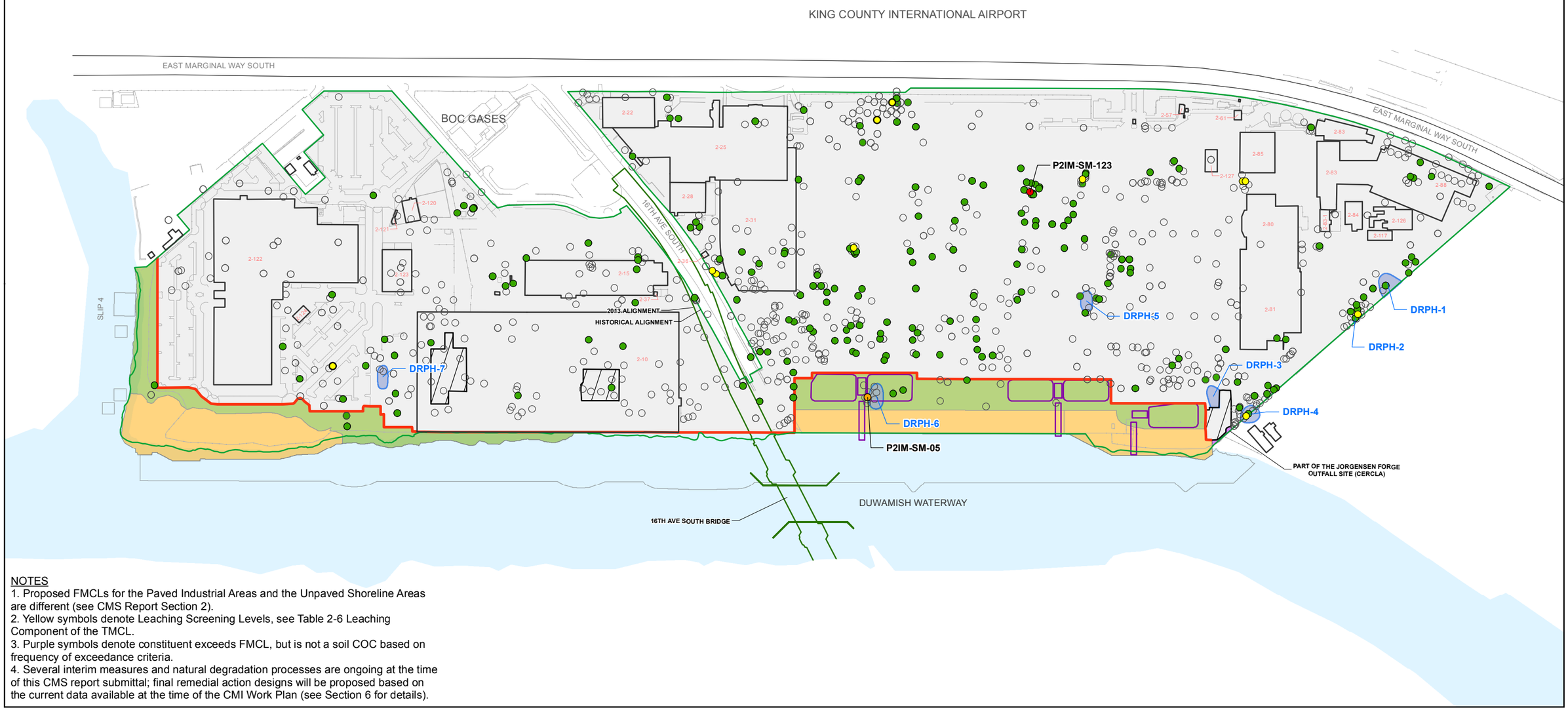
Golder Associates



NOTES
1. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
2. Yellow symbols denote Leaching Screening Levels, see Table 2-6 Leaching Component of the TMCL.
3. Purple symbols denote constituent exceeds FMCL, but is not a soil COC based on frequency of exceedance criteria.
4. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- A-Level Groundwater Exceedance Area

DRPH-1 Exceedance Area Identifier

- Stormwater Swale

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **4-7C**

SOIL DATA (6-11 FEET) AND A-LEVEL GROUNDWATER EXCEEDANCE AREAS CONCENTRATIONS COMPARED TO CLEANUP LEVELS FOR DRPH, MoRPH, OR NAPHTHALENE

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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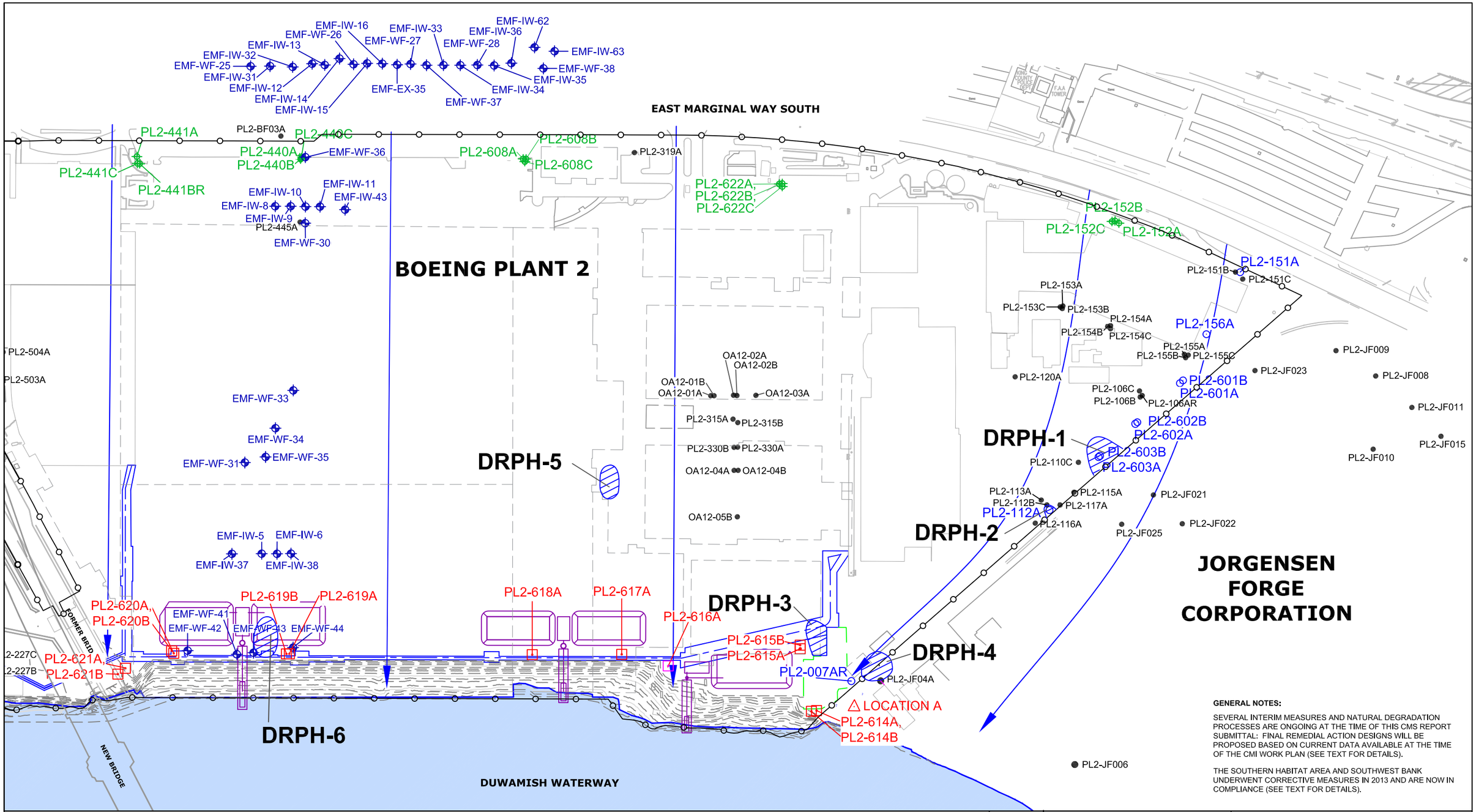
Golder Associates



GENERAL NOTES:

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THE SOUTHERN HABITAT AREA AND SOUTHWEST BANK UNDERWENT CORRECTIVE MEASURES IN 2013 AND ARE NOW IN COMPLIANCE (SEE TEXT FOR DETAILS).

KEY:

- PROPOSED NEW SHORELINE MONITORING WELL
- CURRENT SHORELINE MONITORING WELL
- CURRENT SHORELINE MONITORING WELL NOT PROPOSED FOR FUTURE SHORELINE MONITORING
- UPGRADIENT MONITORING WELL
- PROPERTY BOUNDARY MONITORING WELL
- CURRENT EMF WELL (IW = INJECTION WF = MONITORING)
- OTHER EXISTING WELL
- PROPERTY LINE AS SPECIFIED IN AGREED ORDER
- BUILDINGS
- FORMER BUILDINGS
- DUCT BANK
- SHEETPILE CONTAINMENT STRUCTURE
- STORMWATER SWALES
- A-LEVEL EXCEEDANCES
- B-LEVEL EXCEEDANCES
- C-LEVEL EXCEEDANCES

N

0 50 100 200

SCALE: 1" = 200'

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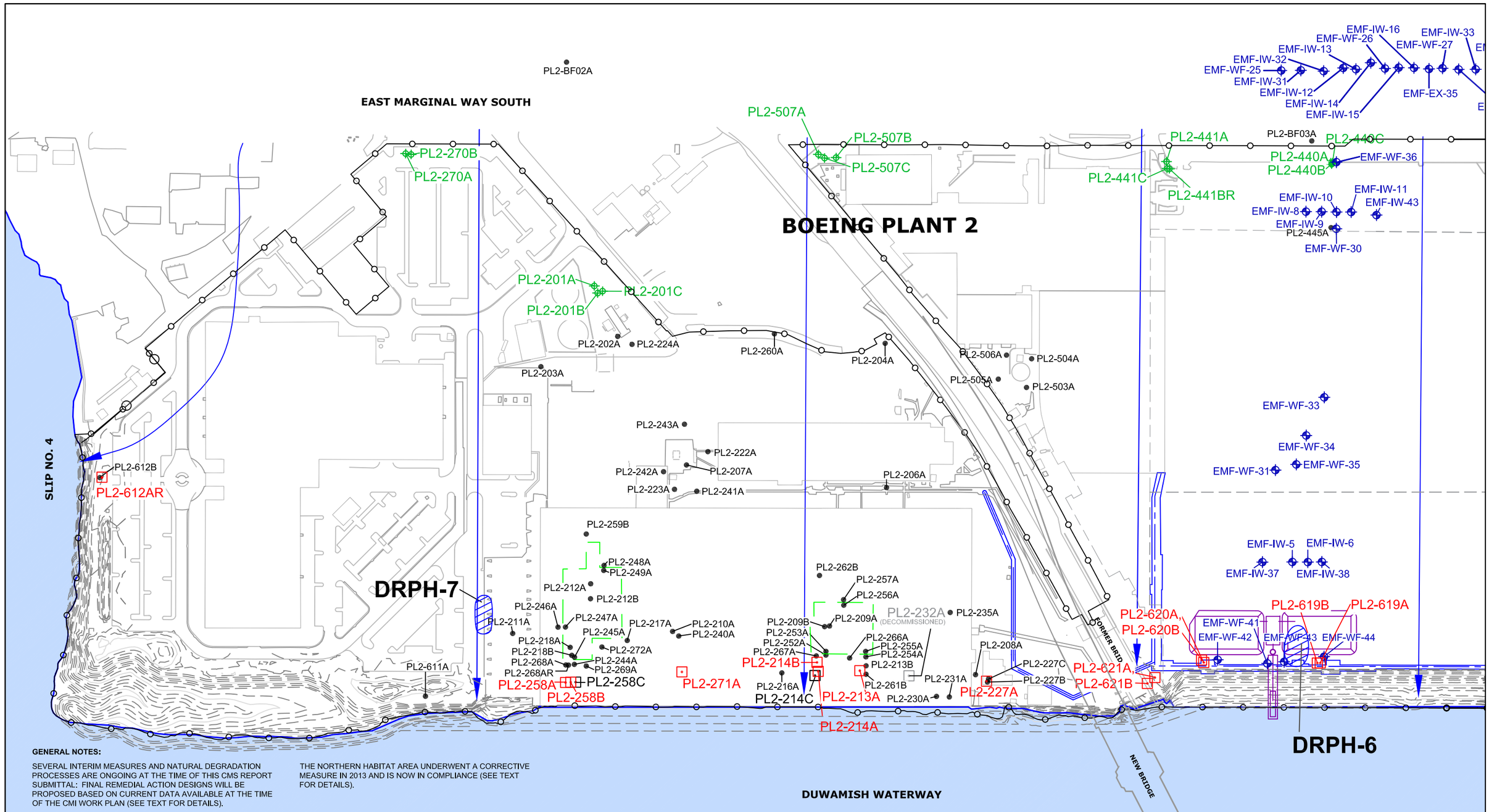
APPROXIMATE GROUNDWATER FLOW DIRECTION BASED ON RCRA FACILITY GROUNDWATER INVESTIGATION INTERIM REPORT, VOLUME V (WESTON, 1996) AND CONCEPTUAL HYDROLOGIC MODEL DATA GAP INVESTIGATION RESULTS (EPI, 2005)

PROJECT	BOEING PLANT 2		
PREPARED FOR	THE BOEING COMPANY		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILA, WASHINGTON		
SHEET 1 of 1	DRAWN BY VPB	REVIEWED BY DCK	DATE 10/6/17

ENVIRONMENTAL PARTNERS INC
1180 NW Maple Street, Suite 310
Issaquah, Washington 98027

FIGURE 4-7D

AREAS WITH DRPH, MoRPH, OR NAPHTHALENE CONCENTRATIONS EXCEEDING PROPOSED FMCLs SOUTH PLANT 2



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KEY:

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- CURRENT SHORELINE MONITORING WELL
- CURRENT SHORELINE MONITORING WELL NOT PROPOSED FOR FUTURE SHORELINE MONITORING
- UPGRADIENT MONITORING WELL
- PROPERTY BOUNDARY MONITORING WELL
- CURRENT EMF WELL (IW = INJECTION WF = MONITORING)
- OTHER EXISTING WELL
- PROPERTY LINE AS SPECIFIED IN AGREED ORDER
- BUILDINGS
- FORMER BUILDINGS
- DUCT BANK
- SHEETPILE CONTAINMENT STRUCTURE
- STORMWATER SWALES
- A-LEVEL EXCEEDANCES
- B-LEVEL EXCEEDANCES
- C-LEVEL EXCEEDANCES

N

0 50 100 200

SCALE: 1" = 200'

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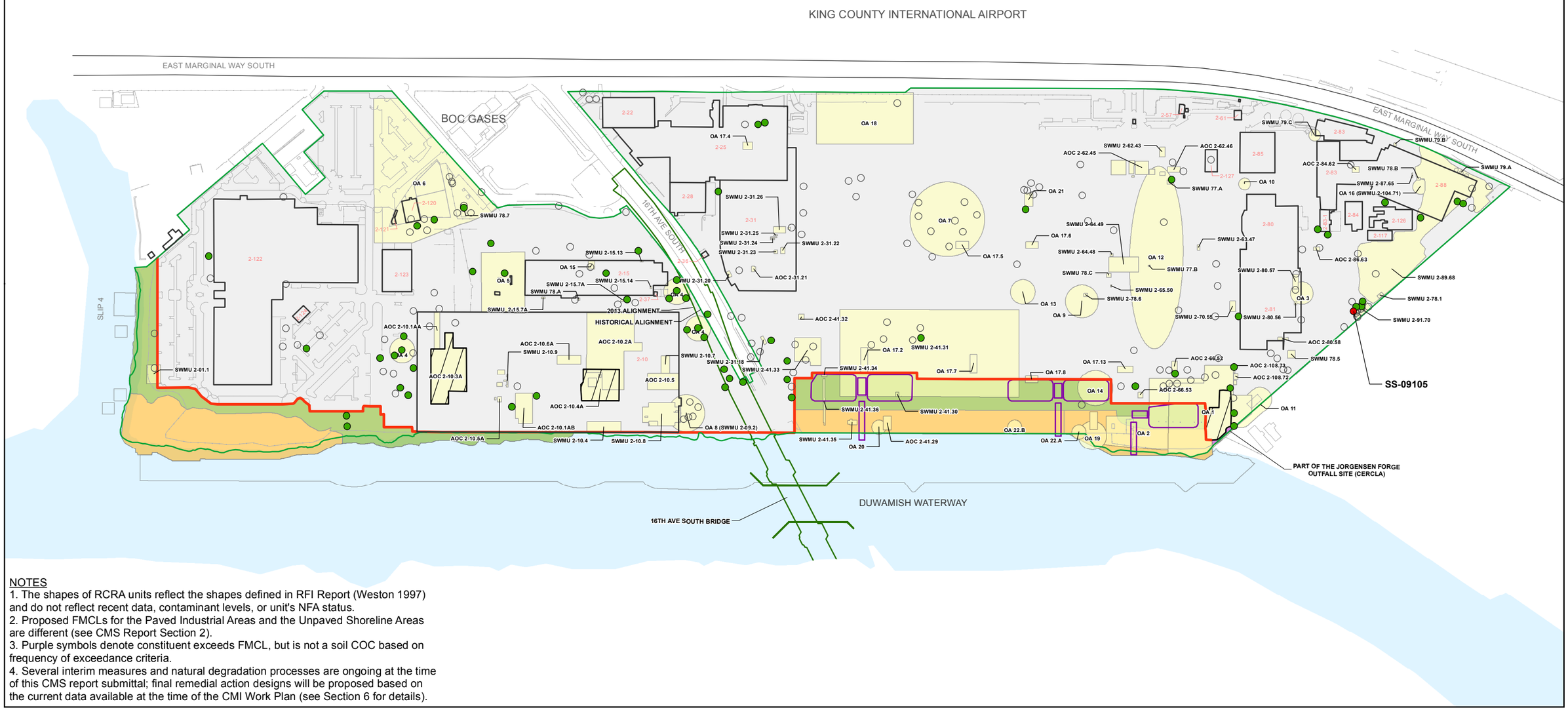
APPROXIMATE GROUNDWATER FLOW DIRECTION BASED ON RCRA FACILITY GROUNDWATER INVESTIGATION INTERIM REPORT, VOLUME V (WESTON, 1996) AND CONCEPTUAL HYDROLOGIC MODEL DATA GAP INVESTIGATION RESULTS (EPI, 2005)

PROJECT	BOEING PLANT 2		
PREPARED FOR	THE BOEING COMPANY		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILA, WASHINGTON		
SHEET 1 of 1	DRAWN BY VPB	REVIEWED BY DCK	DATE 10/11/17

ENVIRONMENTAL PARTNERS INC
1180 NW Maple Street, Suite 310
Issaquah, Washington 98027

FIGURE 4-7E

AREAS WITH DRPH, MoRPH, OR NAPHTHALENE CONCENTRATIONS EXCEEDING PROPOSED FMCL NORTH PLANT 2



NOTES
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4. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **4-8A**
PCBs SOIL DATA (0-1 FEET)
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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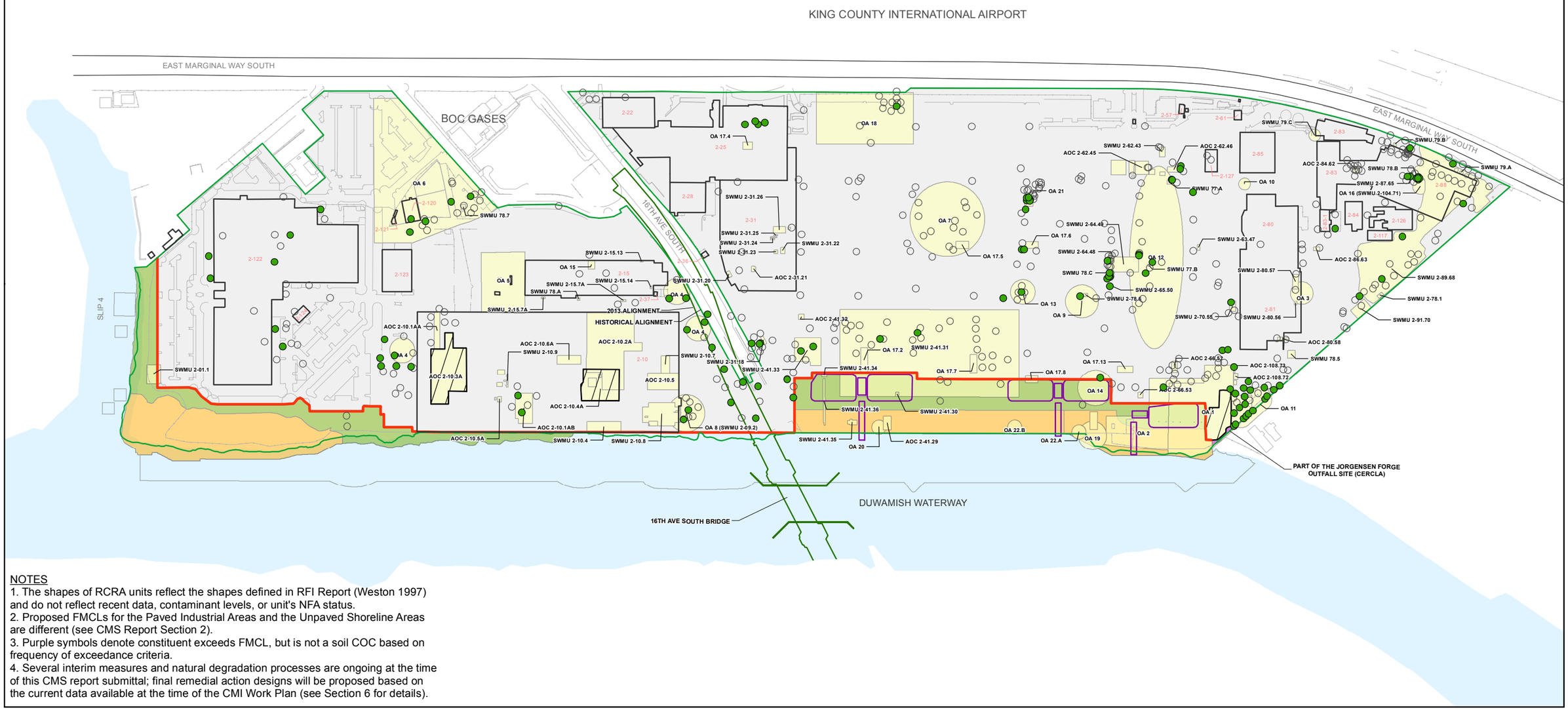
Golder Associates



NOTES
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2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. Purple symbols denote constituent exceeds FMCL, but is not a soil COC based on frequency of exceedance criteria.
4. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

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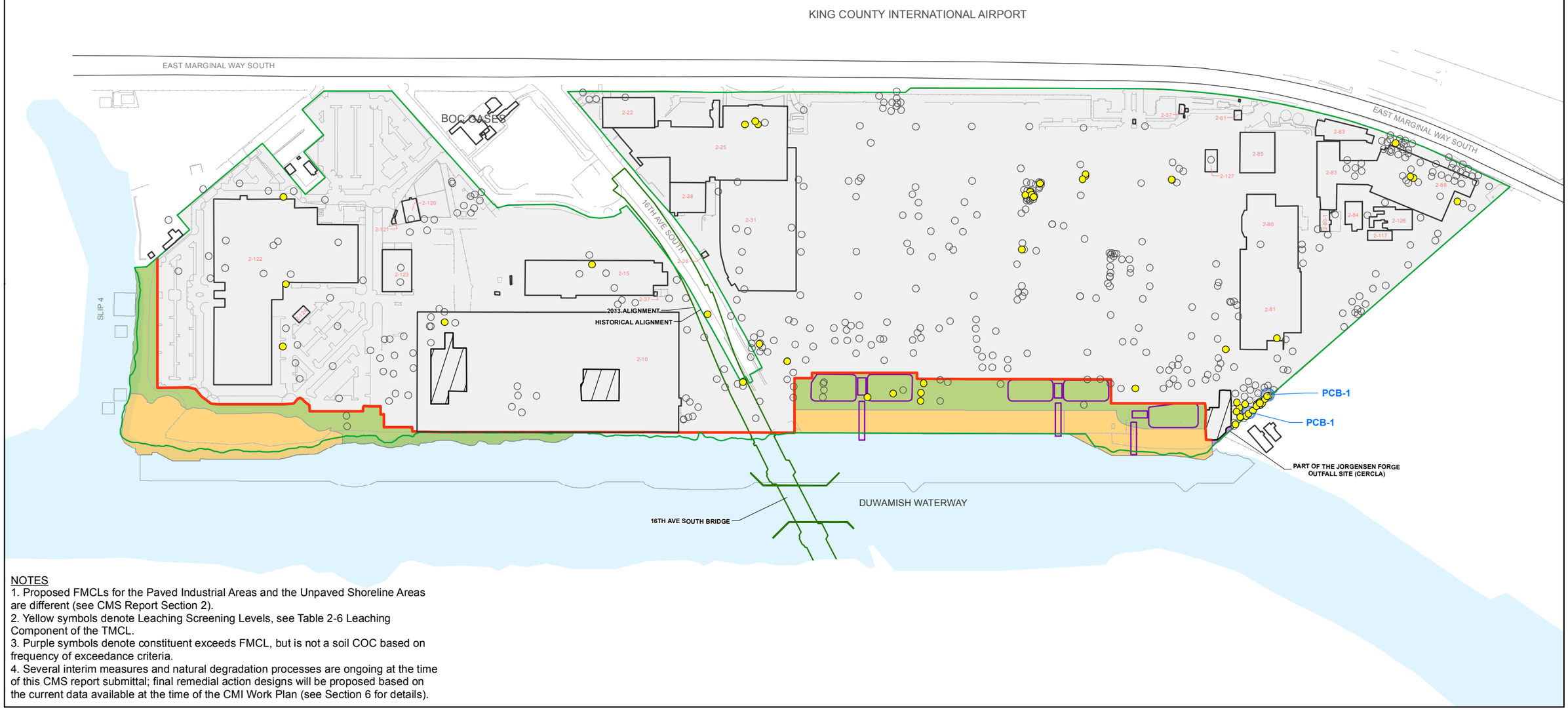
FIGURE **4-8B**
PCBs SOIL DATA (1-6 FEET)
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

Path: G:\Boeing\Plant 2\99_PROJECTS\0131646017_CMS_CONSTRUCTION_SUPPORT\100_CMS_SOB_CMI\02_PRODUCTION\MXD\FIGURES\CMS_Report\Rev0\0131646017_100_045_F4_8B_Rev0_PCB_1_6.mxd Date: 11/2/2017 User: HJackson

Golder Associates



NOTES
1. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
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LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- A-Level Groundwater Exceedance Area
- **PCB-1** Exceedance Area Identifier
- Stormwater Swale

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **4-8C**

SOIL DATA (6-11 FEET) AND A-LEVEL GROUNDWATER EXCEEDANCE AREAS CONCENTRATIONS COMPARED TO CLEANUP LEVELS FOR PCBs

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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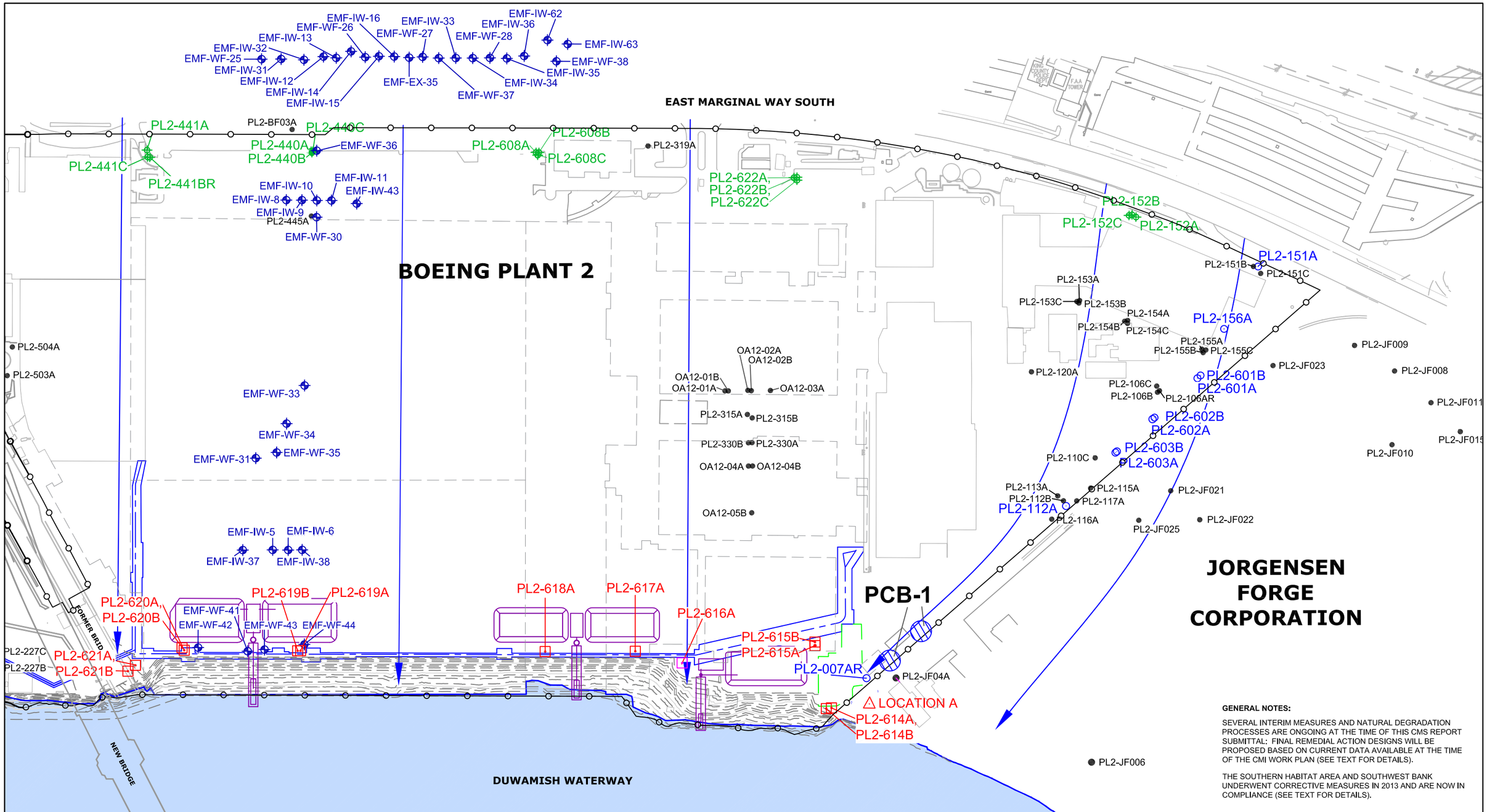
Golder Associates



GENERAL NOTES:

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KEY:

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- CURRENT SHORELINE MONITORING WELL
- CURRENT SHORELINE MONITORING WELL NOT PROPOSED FOR FUTURE SHORELINE MONITORING
- UPGRADIENT MONITORING WELL
- PROPERTY BOUNDARY MONITORING WELL
- CURRENT EMF WELL (IW = INJECTION WF = MONITORING)
- OTHER EXISTING WELL
- PROPERTY LINE AS SPECIFIED IN AGREED ORDER
- BUILDINGS
- FORMER BUILDINGS
- DUCT BANK
- SHEETPILE CONTAINMENT STRUCTURE
- STORMWATER SWALES
- A-LEVEL EXCEEDANCES
- B-LEVEL EXCEEDANCES
- C-LEVEL EXCEEDANCES

N

0 50 100 200

SCALE: 1" = 200'

THIS FIGURE WAS ORIGINALLY PRODUCED IN COLOR. REPRODUCTION IN BLACK AND WHITE MAY RESULT IN LOSS OF INFORMATION.

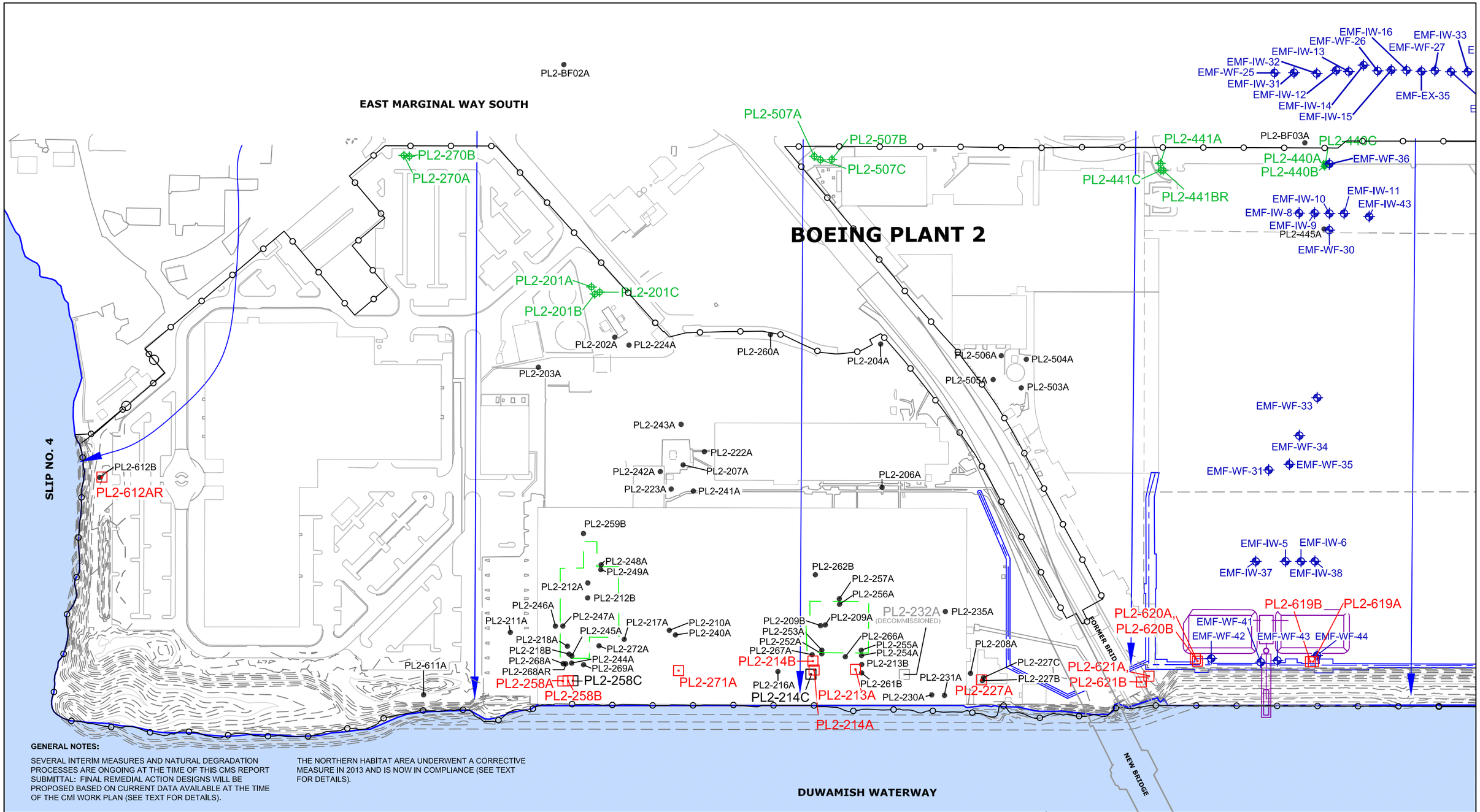
APPROXIMATE GROUNDWATER FLOW DIRECTION BASED ON RCRA FACILITY GROUNDWATER INVESTIGATION INTERIM REPORT, VOLUME V (WESTON, 1996) AND CONCEPTUAL HYDROLOGIC MODEL DATA GAP INVESTIGATION RESULTS (EPI, 2005)

PROJECT	BOEING PLANT 2		
PREPARED FOR	THE BOEING COMPANY		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILA, WASHINGTON		
SHEET 1 of 1	DRAWN BY VPB	REVIEWED BY DCK	DATE 10/6/17

ENVIRONMENTAL PARTNERS INC
1180 NW Maple Street, Suite 310
Issaquah, Washington 98027

FIGURE 4-8D

AREAS WITH TOTAL PCB CONCENTRATIONS EXCEEDING THE PROPOSED FMCL SOUTH PLANT 2



GENERAL NOTES:

SEVERAL INTERIM MEASURES AND NATURAL DEGRADATION PROCESSES ARE ONGOING AT THE TIME OF THIS CMS REPORT SUBMITTAL: FINAL REMEDIAL ACTION DESIGNS WILL BE PROPOSED BASED ON CURRENT DATA AVAILABLE AT THE TIME OF THE CMI WORK PLAN (SEE TEXT FOR DETAILS).

THE NORTHERN HABITAT AREA UNDERWENT A CORRECTIVE MEASURE IN 2013 AND IS NOW IN COMPLIANCE (SEE TEXT FOR DETAILS).

KEY:

N

0 50 100 200

SCALE: 1" = 200'

- PROPOSED NEW SHORELINE MONITORING WELL
- CURRENT SHORELINE MONITORING WELL
- CURRENT SHORELINE MONITORING WELL NOT PROPOSED FOR FUTURE SHORELINE MONITORING
- UPGRADIENT MONITORING WELL
- PROPERTY BOUNDARY MONITORING WELL
- CURRENT EMF WELL (IW = INJECTION WF = MONITORING)
- OTHER EXISTING WELL
- PROPERTY LINE AS SPECIFIED IN AGREED ORDER
- BUILDINGS
- FORMER BUILDINGS
- DUCT BANK
- SHEETPILE CONTAINMENT STRUCTURE
- STORMWATER SWALES
- A-LEVEL EXCEEDANCES
- B-LEVEL EXCEEDANCES
- C-LEVEL EXCEEDANCES

THIS FIGURE WAS ORIGINALLY PRODUCED IN COLOR. REPRODUCTION IN BLACK AND WHITE MAY RESULT IN LOSS OF INFORMATION.

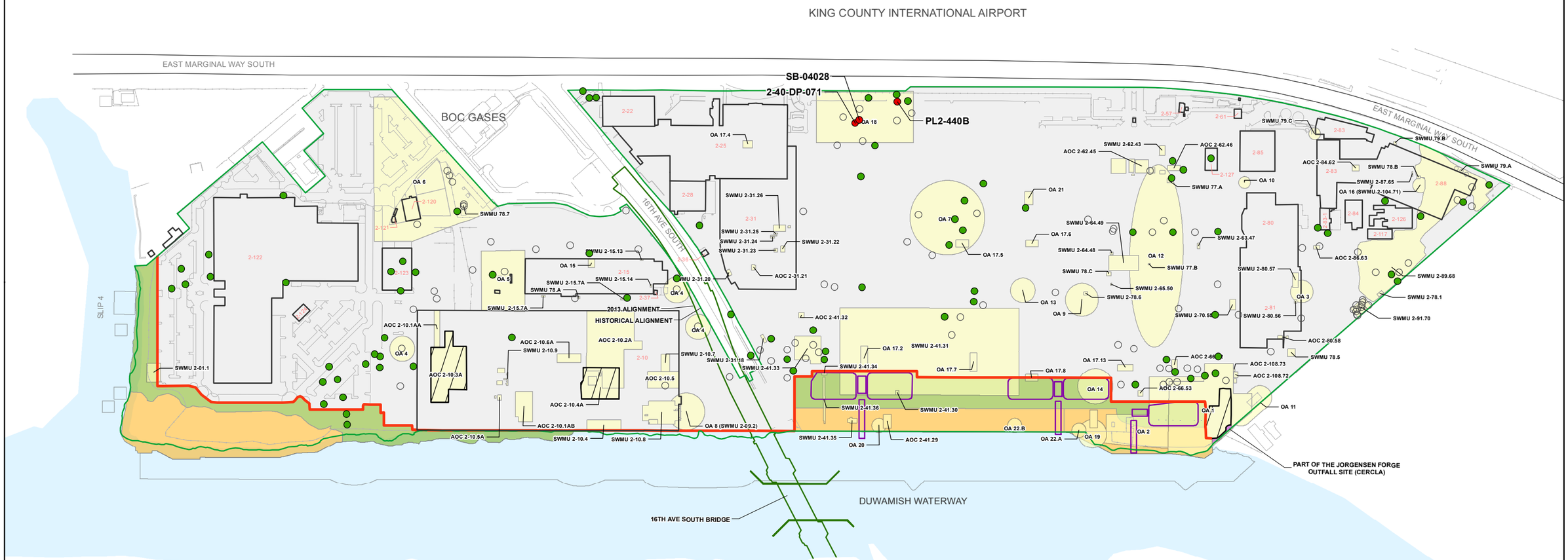
APPROXIMATE GROUNDWATER FLOW DIRECTION BASED ON RCRA FACILITY GROUNDWATER INVESTIGATION INTERIM REPORT, VOLUME V (WESTON, 1996) AND CONCEPTUAL HYDROLOGIC MODEL DATA GAP INVESTIGATION RESULTS (EPI, 2005)

PROJECT	BOEING PLANT 2		
PREPARED FOR	THE BOEING COMPANY		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILA, WASHINGTON		
SHEET 1 of 1	DRAWN BY VPB	REVIEWED BY DCK	DATE 10/11/17

ENVIRONMENTAL PARTNERS INC
1180 NW Maple Street, Suite 310
Issaquah, Washington 98027

FIGURE 4-8E

AREAS WITH TOTAL PCB CONCENTRATIONS EXCEEDING THE PROPOSED FMCL NORTH PLANT 2



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. Purple symbols denote constituent exceeds FMCL, but is not a soil COC based on frequency of exceedance criteria.
4. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **4-9A**
cPAHs SOIL DATA (0-1 FEET)
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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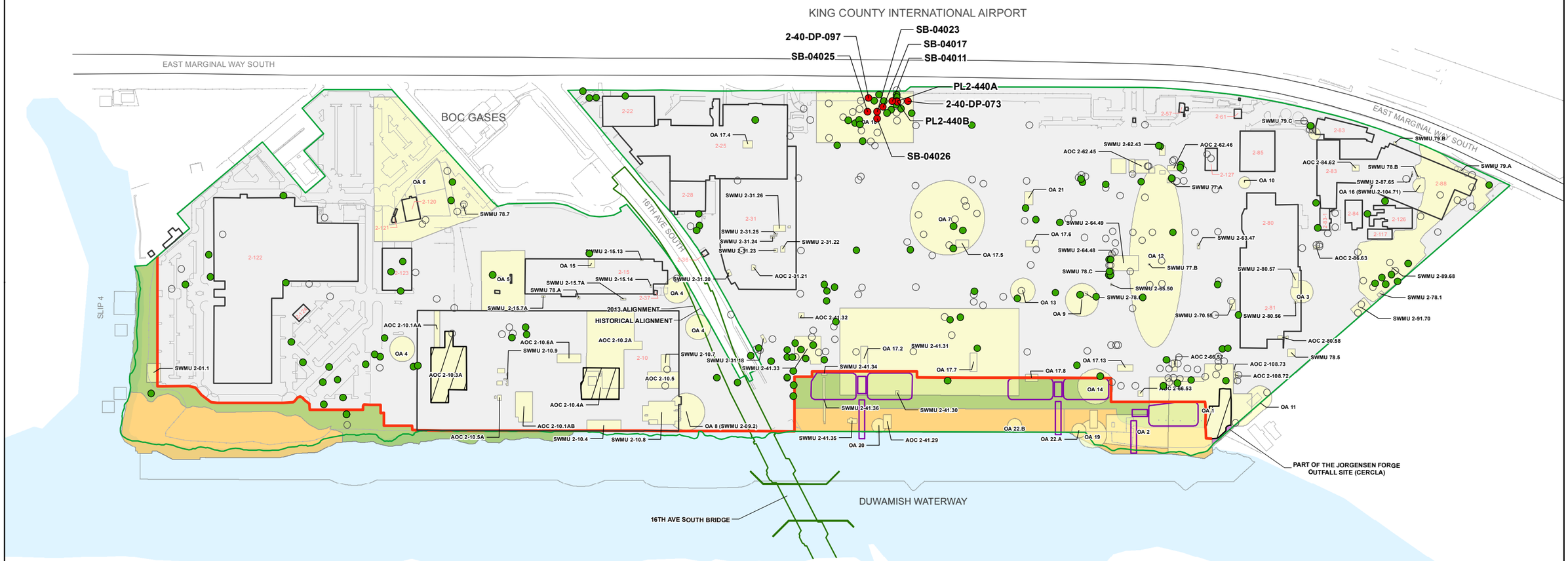
Golder Associates



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. Purple symbols denote constituent exceeds FMCL, but is not a soil COC based on frequency of exceedance criteria.
4. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

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FIGURE **4-9B**
cPAHs SOIL DATA (1-6 FEET)
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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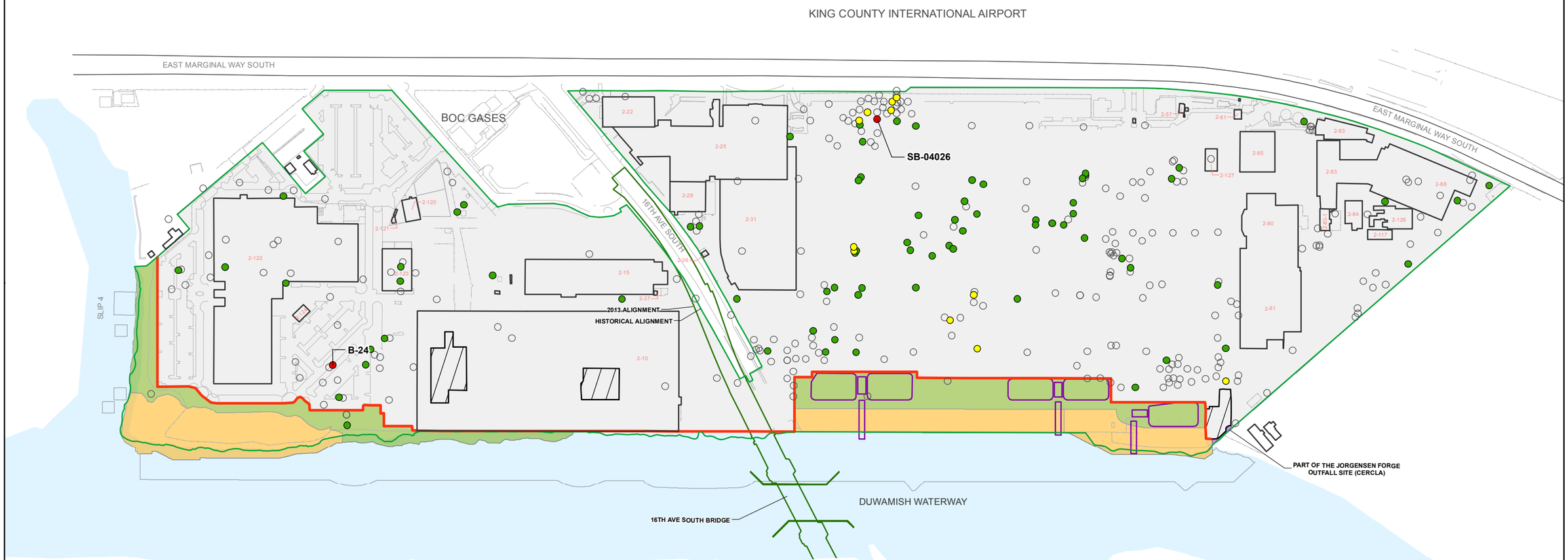
Golder Associates



NOTES
1. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
2. Yellow symbols denote Leaching Screening Levels, see Table 2-6 Leaching Component of the TMCL.
3. There are no groundwater exceedance areas for cPAH.
4. Purple symbols denote constituent exceeds FMCL, but is not a soil COC based on frequency of exceedance criteria.
5. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

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FIGURE **4-9C**

SOIL DATA (6-11 FEET) AND A-LEVEL GROUNDWATER EXCEEDANCE AREAS CONCENTRATIONS COMPARED TO CLEANUP LEVELS FOR cPAHs

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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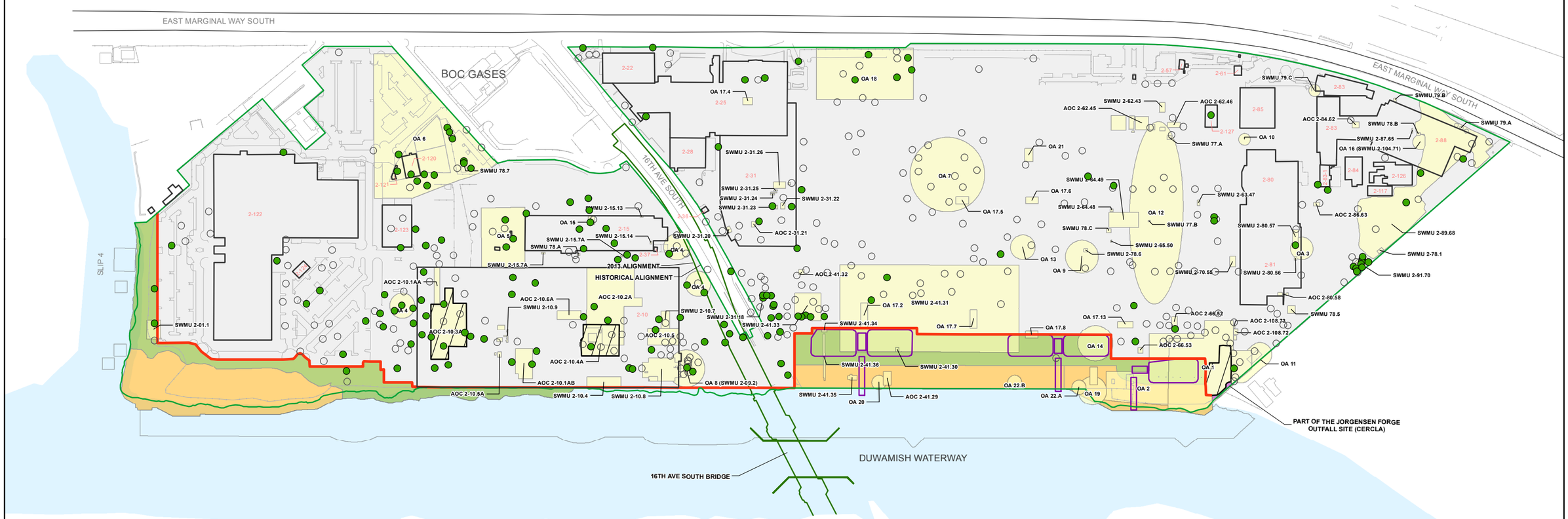
Golder Associates

KING COUNTY INTERNATIONAL AIRPORT



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. Purple symbols denote constituent exceeds FMCL, but is not a soil COC based on frequency of exceedance criteria.
4. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

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FIGURE **4-10A**
CADMIUM SOIL DATA (0-1 FEET)
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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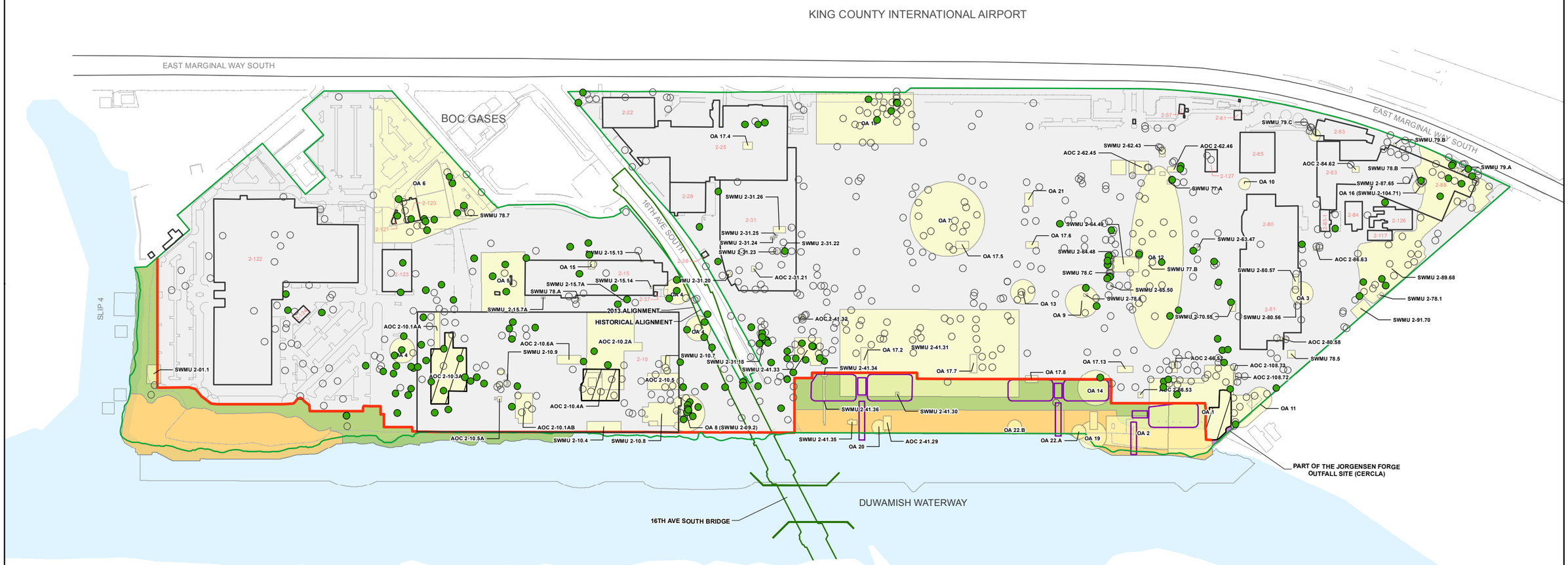
Golder Associates



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. Purple symbols denote constituent exceeds FMCL, but is not a soil COC based on frequency of exceedance criteria.
4. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

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FIGURE **4-10B**
CADMIUM SOIL DATA (1-6 FEET)
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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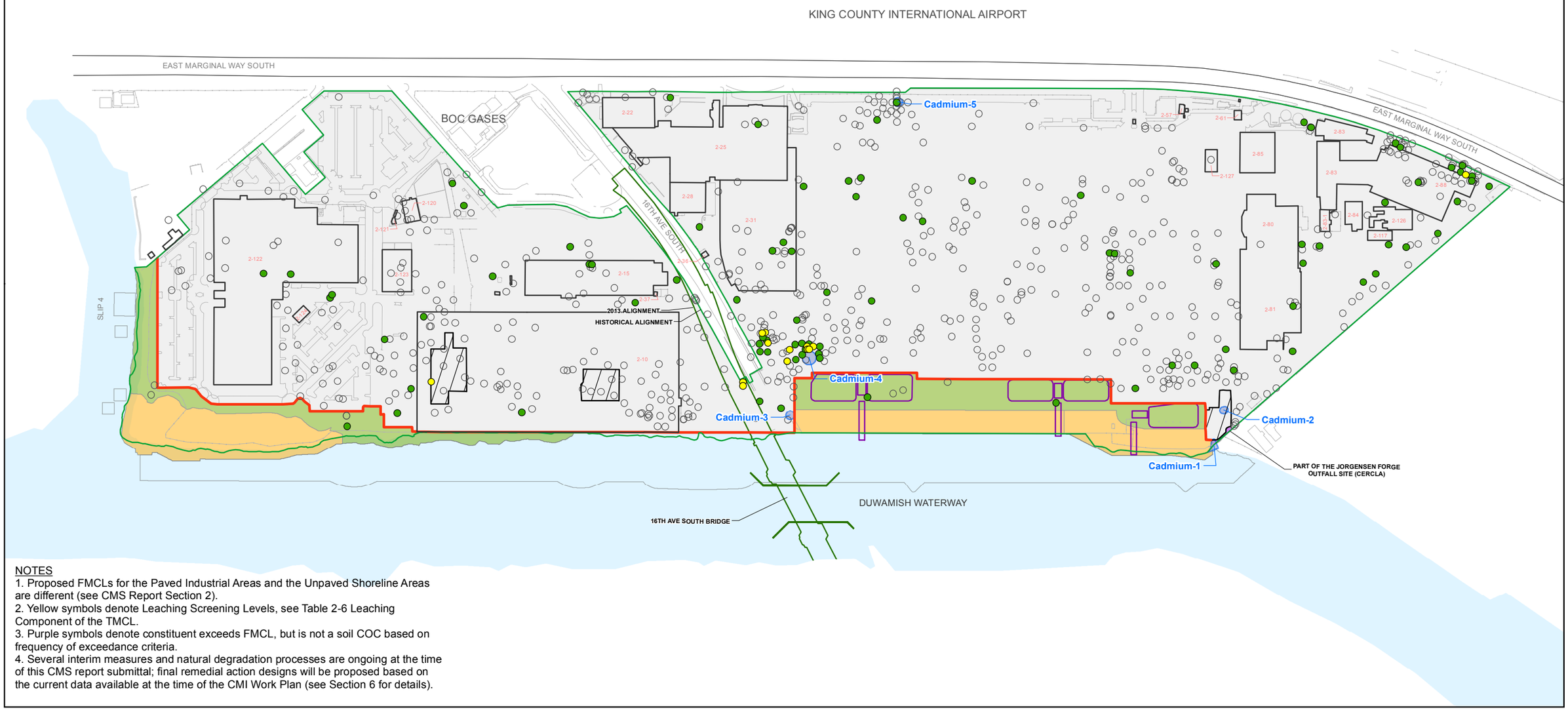
Golder Associates



NOTES
1. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
2. Yellow symbols denote Leaching Screening Levels, see Table 2-6 Leaching Component of the TMCL.
3. Purple symbols denote constituent exceeds FMCL, but is not a soil COC based on frequency of exceedance criteria.
4. Several interim measures and natural degradation processes are ongoing at the time of this CMS report submittal; final remedial action designs will be proposed based on the current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC based on Direct Contact

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- A-Level Groundwater Exceedance Area

Cadmium-1 Exceedance Area Identifier

- Stormwater Swale

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **4-10C**

SOIL DATA (6-11 FEET) AND A-LEVEL GROUNDWATER EXCEEDANCE AREAS CONCENTRATIONS COMPARED TO CLEANUP LEVELS FOR CADMIUM

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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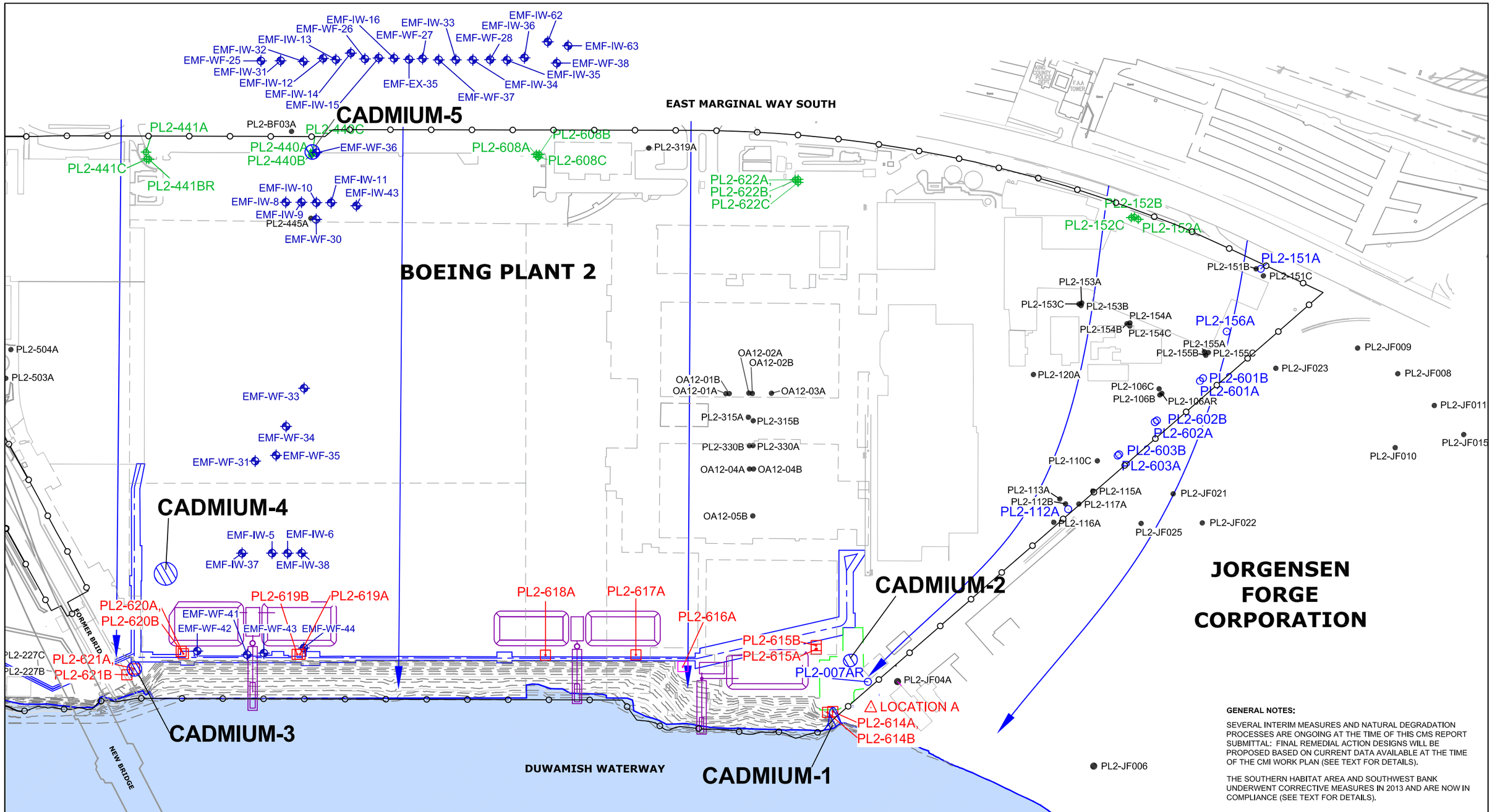

GENERAL NOTES:

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THE SOUTHERN HABITAT AREA AND SOUTHWEST BANK UNDERWENT CORRECTIVE MEASURES IN 2013 AND ARE NOW IN COMPLIANCE (SEE TEXT FOR DETAILS).

KEY:

- PROPOSED NEW SHORELINE MONITORING WELL
- CURRENT SHORELINE MONITORING WELL
- CURRENT SHORELINE MONITORING WELL NOT PROPOSED FOR FUTURE SHORELINE MONITORING
- UPGRADIENT MONITORING WELL
- PROPERTY BOUNDARY MONITORING WELL
- CURRENT EMF WELL (IW = INJECTION WF = MONITORING)
- OTHER EXISTING WELL
- PROPERTY LINE AS SPECIFIED IN AGREED ORDER
- BUILDINGS
- FORMER BUILDINGS
- DUCT BANK
- SHEETPILE CONTAINMENT STRUCTURE
- STORMWATER SWALES
- A-LEVEL EXCEEDANCES
- B-LEVEL EXCEEDANCES
- C-LEVEL EXCEEDANCES

N

0 50 100 200

SCALE: 1" = 200'

THIS FIGURE WAS ORIGINALLY PRODUCED IN COLOR. REPRODUCTION IN BLACK AND WHITE MAY RESULT IN LOSS OF INFORMATION.

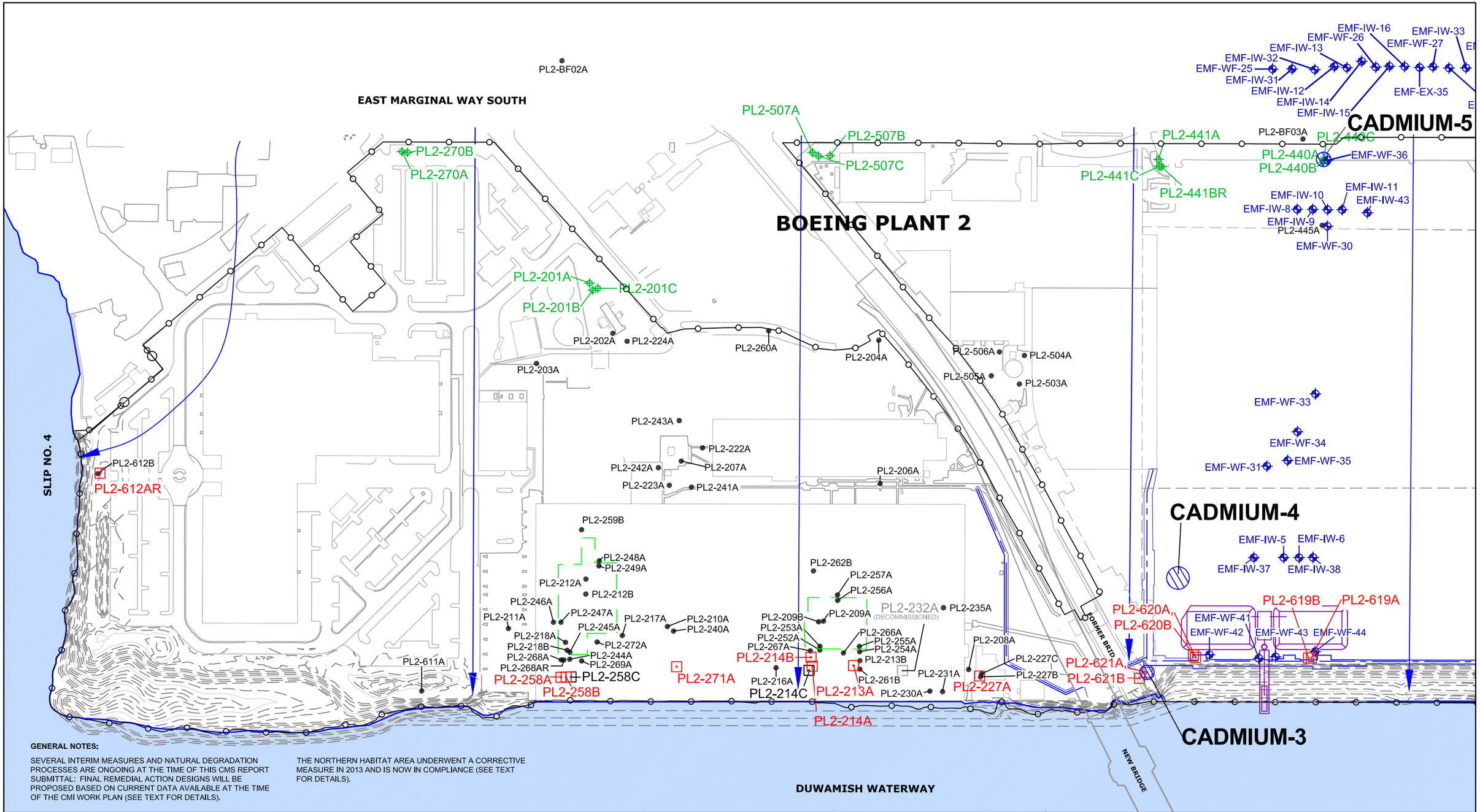
APPROXIMATE GROUNDWATER FLOW DIRECTION BASED ON RCRA FACILITY GROUNDWATER INVESTIGATION INTERIM REPORT, VOLUME V (WESTON, 1996) AND CONCEPTUAL HYDROLOGIC MODEL DATA GAP INVESTIGATION RESULTS (EPI, 2005)

PROJECT	BOEING PLANT 2		
PREPARED FOR	THE BOEING COMPANY		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILA, WASHINGTON		
SHEET 1 of 1	DRAWN BY VPB	REVIEWED BY DCK	DATE 10/12/17

ENVIRONMENTAL PARTNERS INC
1180 NW Maple Street, Suite 310
Issaquah, Washington 98027

FIGURE 4-10D

AREAS WITH CADMIUM CONCENTRATIONS EXCEEDING PROPOSED FMCL SOUTH PLANT 2



GENERAL NOTES:

SEVERAL INTERIM MEASURES AND NATURAL DEGRADATION PROCESSES ARE ONGOING AT THE TIME OF THIS CMS REPORT SUBMITTAL: FINAL REMEDIAL ACTION DESIGNS WILL BE PROPOSED BASED ON CURRENT DATA AVAILABLE AT THE TIME OF THE CMI WORK PLAN (SEE TEXT FOR DETAILS).

THE NORTHERN HABITAT AREA UNDERWENT A CORRECTIVE MEASURE IN 2013 AND IS NOW IN COMPLIANCE (SEE TEXT FOR DETAILS).

KEY:

- PROPOSED NEW SHORELINE MONITORING WELL
- CURRENT SHORELINE MONITORING WELL
- CURRENT SHORELINE MONITORING WELL NOT PROPOSED FOR FUTURE SHORELINE MONITORING
- UPGRADIENT MONITORING WELL
- PROPERTY BOUNDARY MONITORING WELL
- CURRENT EMF WELL (IW = INJECTION WF = MONITORING)
- OTHER EXISTING WELL
- PROPERTY LINE AS SPECIFIED IN AGREED ORDER
- BUILDINGS
- FORMER BUILDINGS
- DUCT BANK
- SHEETPILE CONTAINMENT STRUCTURE
- STORMWATER SWALES
- A-LEVEL EXCEEDANCES
- B-LEVEL EXCEEDANCES
- C-LEVEL EXCEEDANCES

N

0 50 100 200

SCALE: 1" = 200'

THIS FIGURE WAS ORIGINALLY PRODUCED IN COLOR. REPRODUCTION IN BLACK AND WHITE MAY RESULT IN LOSS OF INFORMATION.

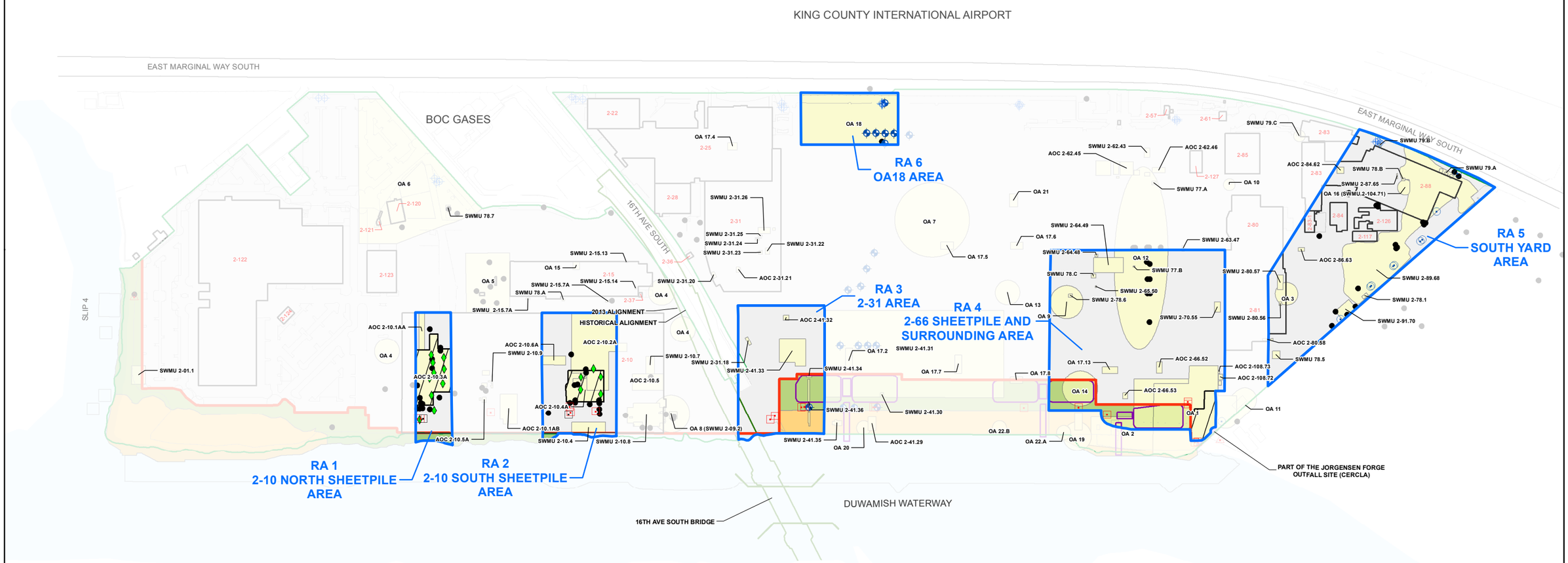
APPROXIMATE GROUNDWATER FLOW DIRECTION BASED ON RCRA FACILITY GROUNDWATER INVESTIGATION INTERIM REPORT, VOLUME V (WESTON, 1996) AND CONCEPTUAL HYDROLOGIC MODEL DATA GAP INVESTIGATION RESULTS (EPI, 2005)

PROJECT	BOEING PLANT 2		
PREPARED FOR	THE BOEING COMPANY		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILA, WASHINGTON		
SHEET 1 of 1	DRAWN BY VPB	REVIEWED BY DCK	DATE 10/12/17

ENVIRONMENTAL PARTNERS INC
1180 NW Maple Street, Suite 310
Issaquah, Washington 98027

FIGURE 4-10E

AREAS WITH CADMIUM CONCENTRATIONS EXCEEDING PROPOSED FMCL NORTH PLANT 2



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).

LEGEND

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)
- Remediation Area RA 1 - RA 6

Risk Management Area

- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Southwest Bank Corrective Measure Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

Wells

- Current EMF Well
- Current Shoreline Monitoring Well
- Current Shoreline Monitoring Well Not Proposed for Future Shoreline Monitoring
- Other Existing Well
- Proposed New Shoreline Monitoring Well
- Proposed Ongoing ERD Injection Well
- Proposed Property Boundary Monitoring Well
- Proposed Upgradient Monitoring Well

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **6-1**
BOEING PLANT 2
REMEDIATION AREAS RA 1 - RA 6
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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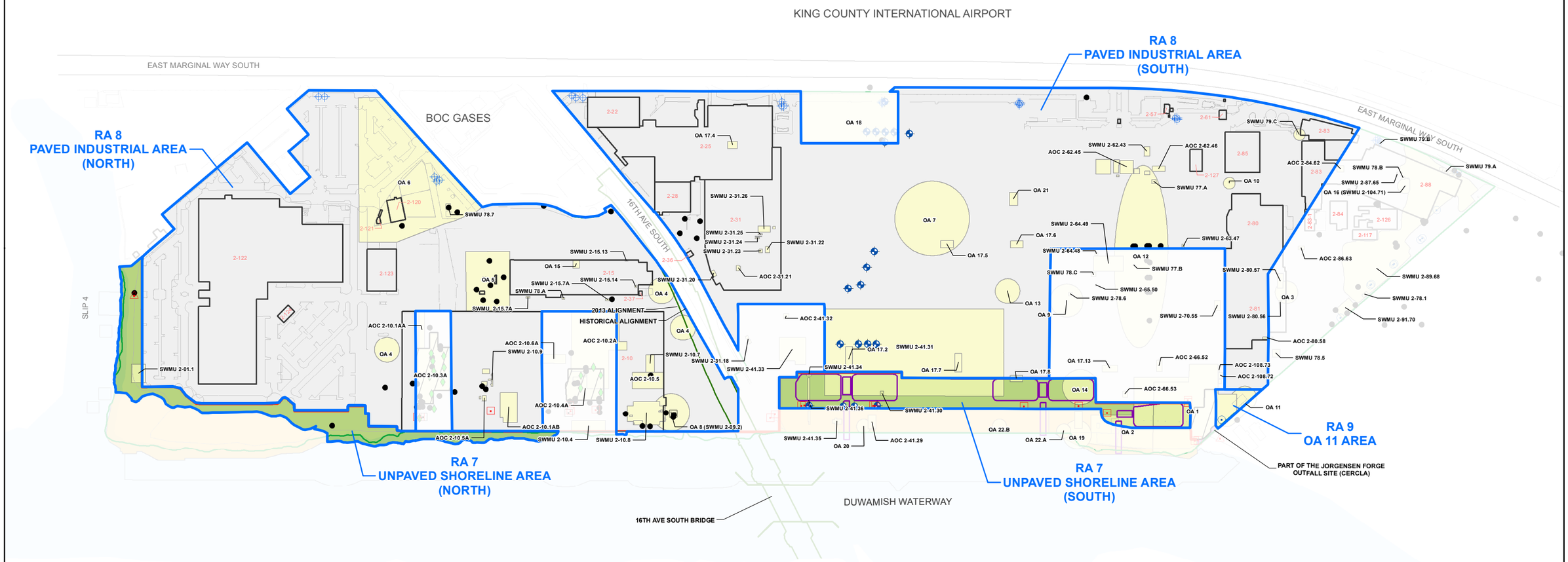

NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. RA 8 comprises the Paved Industrial Area, except for those areas included in other RAs.
4. RA 7 comprises the Unpaved Shoreline Area.

LEGEND

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)
- Remediation Area RA 7 - RA 9

Risk Management Area
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

Wells
- Current EMF Well
- Current Shoreline Monitoring Well
- Current Shoreline Monitoring Well Not Proposed for Future Shoreline Monitoring
- Other Existing Well
- Proposed New Shoreline Monitoring Well
- Proposed Ongoing ERD Injection Well
- Proposed Property Boundary Monitoring Well
- Proposed Upgradient Monitoring Well

0 350
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

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FIGURE **6-2**
BOEING PLANT 2
REMEDIATION AREAS RA 7 - RA 9
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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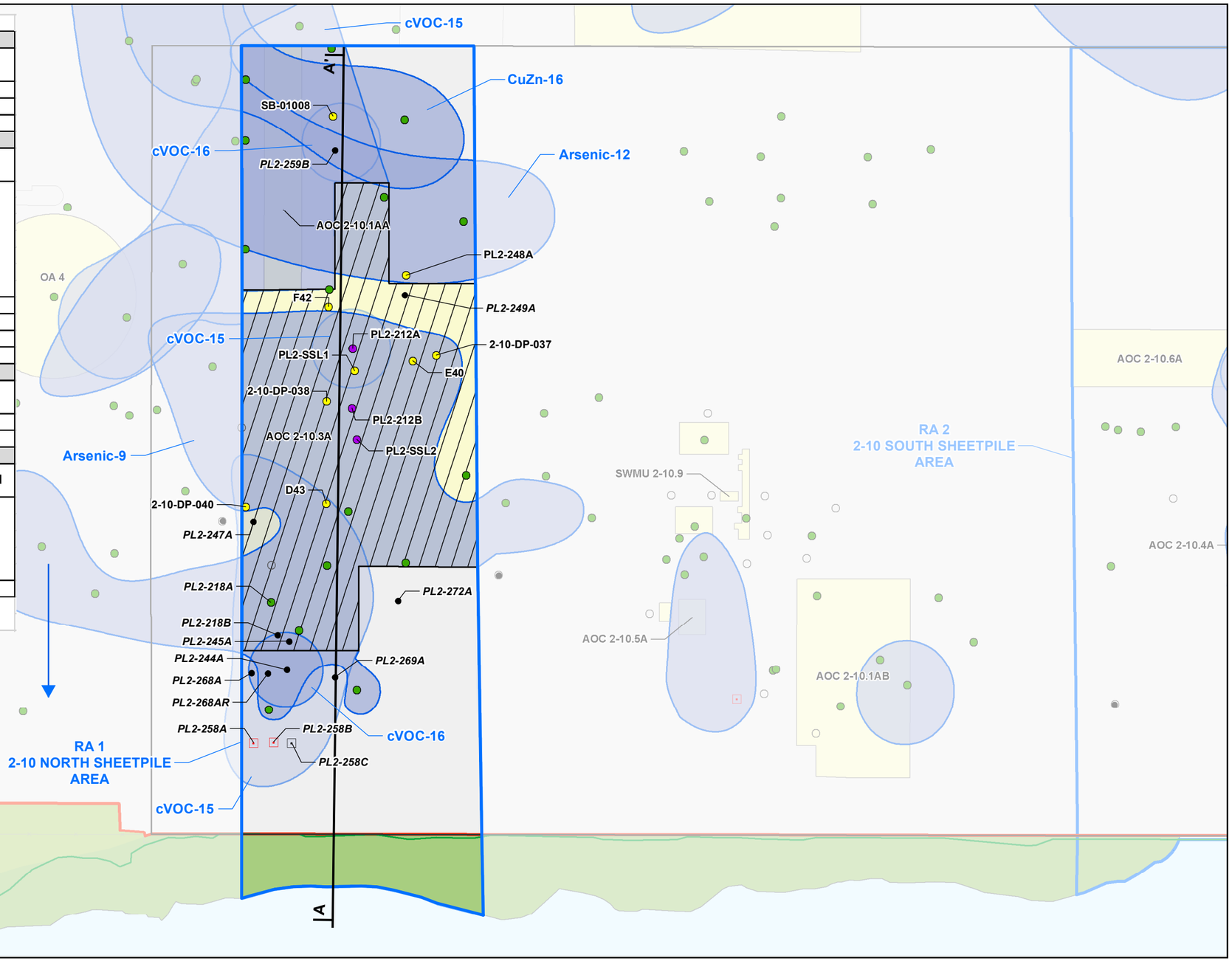
Golder Associates

RA 1 - 2-10 North Sheetpile Area FMCL and SL Exceedance Locations

Constituent	FMCL mg/kg	Soil Sample Location	Concentration mg/kg	Depth feet bgs
Soil Direct Contact (0-11 feet bgs)				
TCE*	19	PL2-212A	23	11
		PL2-SSL2	47	5
		PL2-212B	48	10
Soil Leaching (6-11 feet bgs)				
Constituent	**Leaching SL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
TCE*	0.051	PL2-248A	0.052	10
		F42	0.11	
		D43	0.28	
		E40	0.33	
		2-10-DP-037	2	
		2-10-DP-038	2	
		PL2-SSL1	9.1	
		PL2-SSL2	0.87	10
cis-DCE	2.6	PL2-212A	44	11
		PL2-212B	6.4	10
VC	0.022	PL2-212A	1.8	11
Soil - Leaching Pathway Incomplete (6-11 feet bgs)				
Constituent	**Leaching SL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
Cadmium	3.3	2-10-DP-040	5.6	10
PCB	0.0018	SB-01008	0.04	10
Groundwater				
Constituent	**FMCL µg/L**	**Exceedance Area**	**Concentration µg/L**	**Aquifer Level**
VC	0.20	cVOC-15	0.3 to 1,100	A-Level
TCE	0.70		1.1 to 20	
Arsenic	8.0	Arsenic-9	8.3 to 39.3	
		Arsenic-12	9.0 to 49.8	
Copper	8.0	CuZn-16	9.1 to 17.7	
VC	0.20	cVOC-16	0.3	B-Level

* TCE is not a soil COC; however TCE was detected above the proposed Industrial FMCL at locations PL2-212A, PL2-212B, and PL2-SSL2.



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. The Soil Leaching Screening Levels are applied only to soil in the 6-11 feet bgs interval.
4. Several Interim Measures and natural degradation processes are ongoing at the time of this CMS Report submittal; final remedial action designs will be proposed based on current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC

Wells
- Current EMF Well
- Current Shoreline Monitoring Well
- Current Shoreline Monitoring Well Not Proposed for Future Shoreline Monitoring
- Other Existing Well
- Proposed New Shoreline Monitoring Well
- Proposed Property Boundary Monitoring Well
- Proposed Upgradient Monitoring Well
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)
- Groundwater Flow Direction
- Cross Section A to A'
- Remediation Area
- Groundwater Exceedance Area

Risk Management Areas
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Southwest Bank Corrective Measure Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 60
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **6-3A**

BOEING PLANT 2

RA 1 - 2-10 NORTH SHEETPILE AREA SOIL (0-11 FEET) AND GROUNDWATER EXCEEDANCE AREAS

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

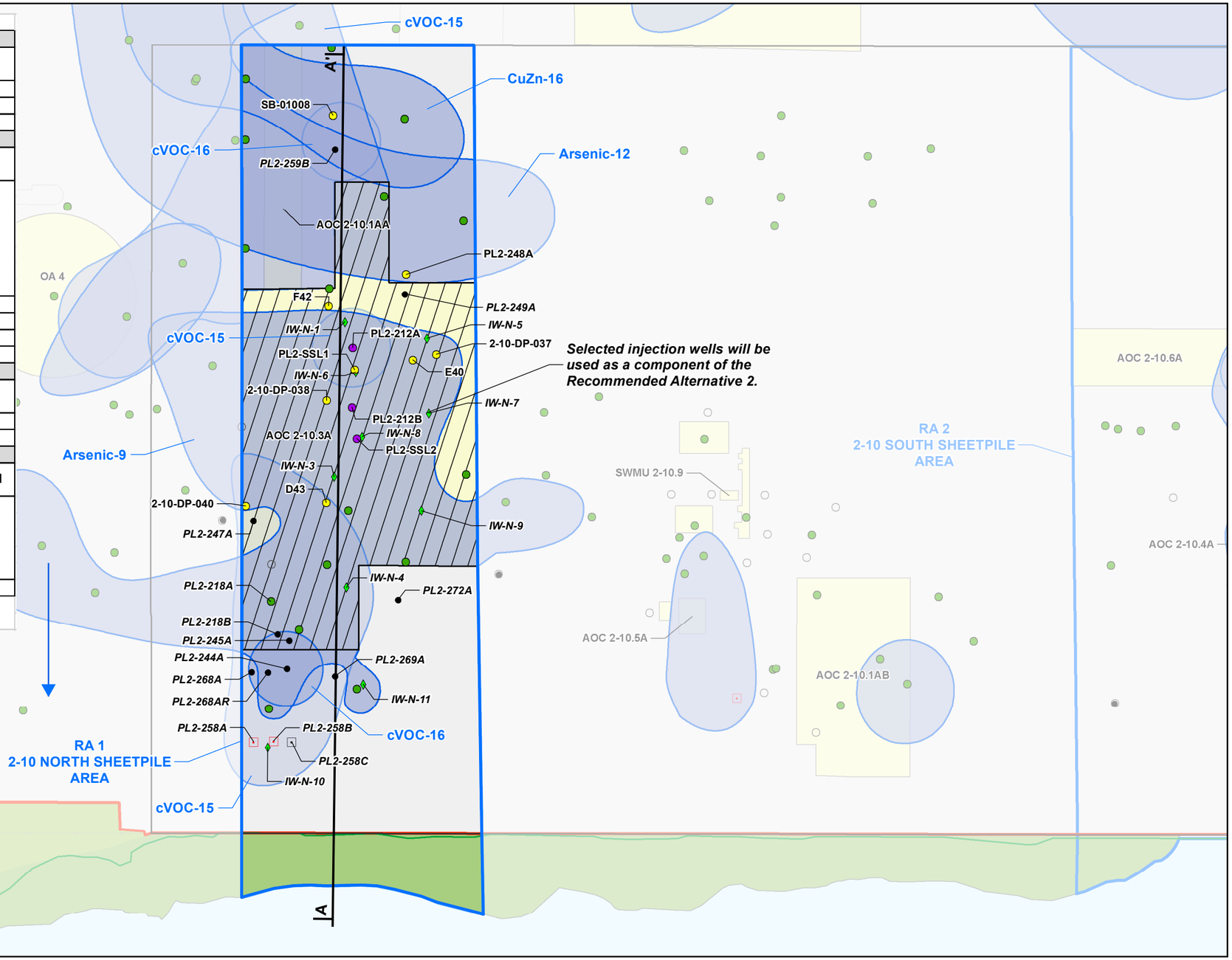
Path: G:\Boeing\Plant 2\99_PROJECTS\0131646017_CMS_CONSTRUCTION_SUPPORT\100_CMS_SOB_CMI\02_PRODUCTION\MXD\FIGURES\CMS_Report\Rev0\0131646017_100_055_F_6_3A_Rev0_2_10_NorthSheetpileAndSurroundingAreaRA1.mxd Date: 10/31/2017 User: HJackson

Golder Associates

RA 1 - 2-10 North Sheetpile Area FMCL and SL Exceedance Locations

Constituent	FMCL mg/kg	Soil Sample Location	Concentration mg/kg	Depth feet bgs
Soil Direct Contact (0-11 feet bgs)				
TCE*	19	PL2-212A	23	11
		PL2-SSL2	47	5
		PL2-212B	48	10
Soil Leaching (6-11 feet bgs)				
Constituent	**Leaching SL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
TCE*	0.051	PL2-248A	0.052	10
		F42	0.11	
		D43	0.28	
		E40	0.33	
		2-10-DP-037	2	
		2-10-DP-038	2	
		PL2-SSL1	9.1	
		PL2-SSL2	0.87	10
cis-DCE	2.6	PL2-212A	44	11
		PL2-212B	6.4	10
VC	0.022	PL2-212A	1.8	11
Soil - Leaching Pathway Incomplete (6-11 feet bgs)				
Constituent	**Leaching SL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
Cadmium	3.3	2-10-DP-040	5.6	10
PCB	0.0018	SB-01008	0.04	10
Groundwater				
Constituent	**FMCL µg/L**	**Exceedance Area**	**Concentration µg/L**	**Aquifer Level**
VC	0.20	cVOC-15	0.3 to 1,100	A-Level
TCE	0.70		1.1 to 20	
Arsenic	8.0	Arsenic-9	8.3 to 39.3	
		Arsenic-12	9.0 to 49.8	
Copper	8.0	CuZn-16	9.1 to 17.7	
VC	0.20	cVOC-16	0.3	B-Level

* TCE is not a soil COC; however TCE was detected above the proposed Industrial FMCL at locations PL2-212A, PL2-212B, and PL2-SSL2.



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. The Soil Leaching Screening Levels are applied only to soil in the 6-11 feet bgs interval.
4. Several Interim Measures and natural degradation processes are ongoing at the time of this CMS Report submittal; final remedial action designs will be proposed based on current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC

Wells
- Current EMF Well
- Current Shoreline Monitoring Well
- Current Shoreline Monitoring Well Not Proposed for Future Shoreline Monitoring
- Other Existing Well
- Proposed New Shoreline Monitoring Well
- Proposed Ongoing ERD Injection Well
- Proposed Property Boundary Monitoring Well
- Proposed Upgradient Monitoring Well

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)
- Groundwater Flow Direction
- Cross Section A to A'
- Remediation Area
- Groundwater Exceedance Area

Risk Management Areas
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Southwest Bank Corrective Measure Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 60
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **6-3B**

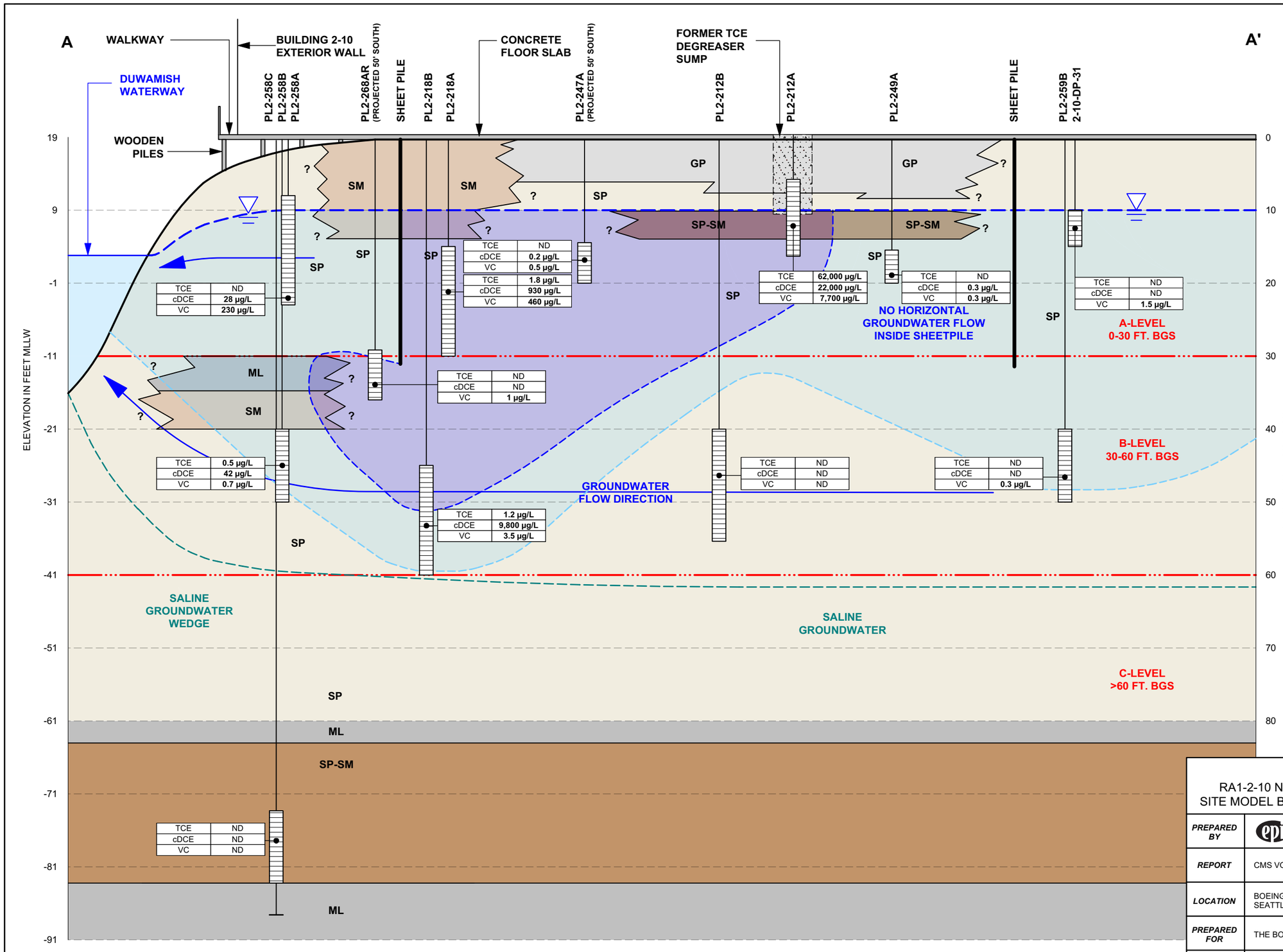
BOEING PLANT 2

RA 1 - 2-10 NORTH SHEETPILE AREA
RECOMMENDED ALTERNATIVE 2

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

Path: G:\Boeing\Plant 2\99_PROJECTS\0131646017_CMS_CONSTRUCTION_SUPPORT\100_CMS_SOB_CMI\02_PRODUCTION\MXD\FIGURES\CMS_Report\Rev0\0131646017_100_056_F_6_3B_Rev0_2_10_NorthSheetpileAndSurroundingAreaRA1.mxd Date: 10/31/2017 User: HJackson

Golder Associates



NOTES:

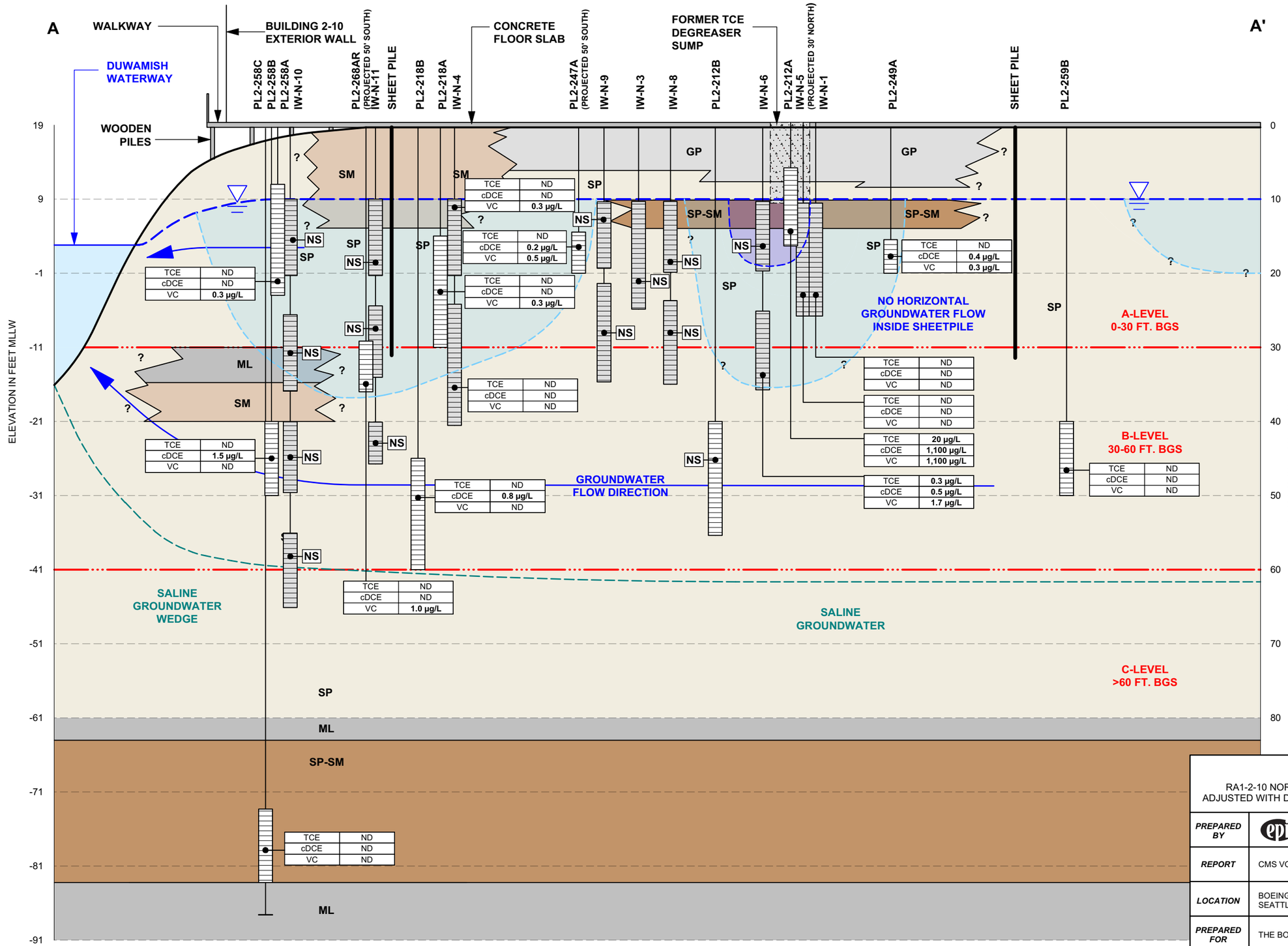
GP	POORLY-GRADED GRAVEL
SM	SILTY SAND
SP	POORLY-GRADED SAND
ML	SILT
SP-SM	POORLY-GRADED SAND WITH SILT
TCE	TRICHLOROETHENE
cDCE	CIS-1,2-DICHLOROETHENE
VC	VINYL CHLORIDE
ND	NOT DETECTED
NS	NOT SAMPLED
µg/L	MICROGRAMS PER LITER
	GROUNDWATER LEVEL
	GROUNDWATER FLOW DIRECTION
	>1,000 µg/L FMCL EXCEEDANCE AREA
	<1,000 µg/L FMCL EXCEEDANCE AREA

PL2-218A — MONITORING WELL ID; WELL SCREEN; TOTAL WELL DEPTH

FIGURE 6-3C

RA1-2-10 NORTH SHEETPILE AREA CONCEPTUAL SITE MODEL BASED ON DATA THROUGH JANUARY 2013

PREPARED BY	ENVIRONMENTAL PARTNERS INC		
REPORT	CMS VOLUME X		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILLA WASHINGTON		
PREPARED FOR	THE BOEING COMPANY		
DATE 10/23/17	DRAWN BY VPB	REVIEWED BY DCK	PROJECT NUMBER 17517.0.100.01



NOTES:

GP	POORLY-GRADED GRAVEL
SM	SILTY SAND
SP	POORLY-GRADED SAND
ML	SILT
SP-SM	POORLY-GRADED SAND WITH SILT
TCE	TRICHLOROETHENE
cDCE	CIS-1,2-DICHLOROETHENE
VC	VINYL CHLORIDE
ND	NOT DETECTED
NS	NOT SAMPLED
µg/L	MICROGRAMS PER LITER
	GROUNDWATER LEVEL
	GROUNDWATER FLOW DIRECTION
	>1,000 µg/L FMCL EXCEEDANCE AREA
	<1,000 µg/L FMCL EXCEEDANCE AREA

PL2-218A — MONITORING WELL ID; WELL SCREEN; TOTAL WELL DEPTH

IW-N-1 — INJECTION WELL ID; WELL SCREEN; TOTAL WELL DEPTH

FIGURE 6-3D

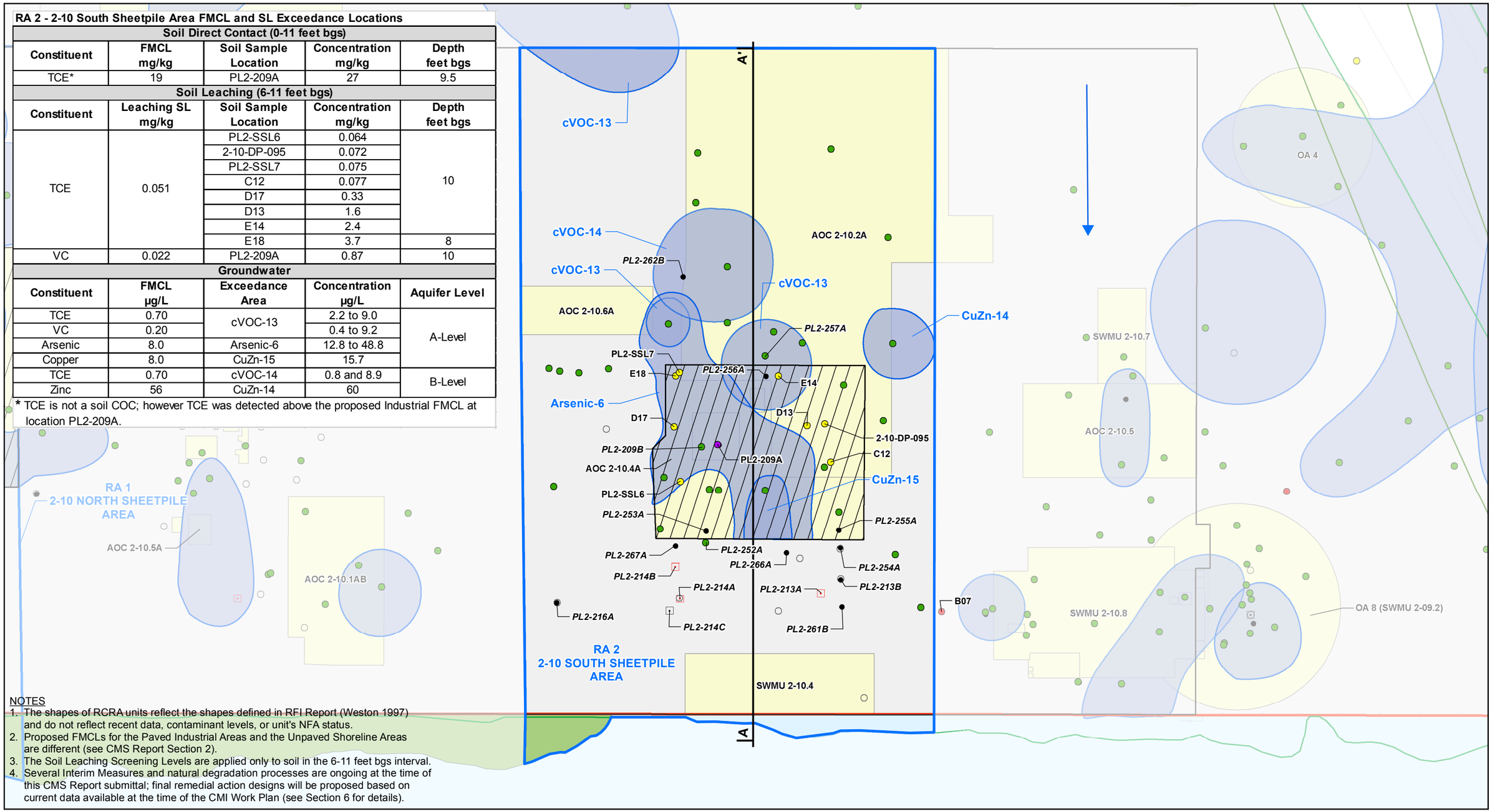
RA1-2-10 NORTH SHEETPILE AREA CONCEPTUAL SITE MODEL
ADJUSTED WITH DATA THROUGH DECEMBER 2016 WHERE APPLICABLE

PREPARED BY	ENVIRONMENTAL PARTNERS INC		
REPORT	CMS VOLUME X		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILLA WASHINGTON		
PREPARED FOR	THE BOEING COMPANY		
DATE 10/23/17	DRAWN BY VPB	REVIEWED BY DCK	PROJECT NUMBER 17517.0.100.01

RA 2 - 2-10 South Sheetpile Area FMCL and SL Exceedance Locations

Soil Direct Contact (0-11 feet bgs)				
Constituent	**FMCL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
TCE*	19	PL2-209A	27	9.5
Soil Leaching (6-11 feet bgs)				
Constituent	**Leaching SL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
TCE	0.051	PL2-SSL6	0.064	10
		2-10-DP-095	0.072	
		PL2-SSL7	0.075	
		C12	0.077	
		D17	0.33	
		D13	1.6	
		E14	2.4	
		E18	3.7	8
VC	0.022	PL2-209A	0.87	10
Groundwater				
Constituent	**FMCL µg/L**	**Exceedance Area**	**Concentration µg/L**	**Aquifer Level**
TCE	0.70	cVOC-13	2.2 to 9.0	A-Level
VC	0.20		0.4 to 9.2	
Arsenic	8.0	Arsenic-6	12.8 to 48.8	
Copper	8.0	CuZn-15	15.7	
TCE	0.70	cVOC-14	0.8 and 8.9	B-Level
Zinc	56	CuZn-14	60	

* TCE is not a soil COC; however TCE was detected above the proposed Industrial FMCL at location PL2-209A.



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. The Soil Leaching Screening Levels are applied only to soil in the 6-11 feet bgs interval.
4. Several Interim Measures and natural degradation processes are ongoing at the time of this CMS Report submittal; final remedial action designs will be proposed based on current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC

Wells
- Current EMF Well
- Current Shoreline Monitoring Well
- Current Shoreline Monitoring Well Not Proposed for Future Shoreline Monitoring
- Other Existing Well
- Proposed New Shoreline Monitoring Well
- Proposed Property Boundary Monitoring Well
- Proposed Upgradient Monitoring Well
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)
- Groundwater Flow Direction
- Cross Section A to A'
- Remediation Area
- Groundwater Exceedance Area

Risk Management Areas
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Southwest Bank Corrective Measure Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 60
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **6-4A**

BOEING PLANT 2
RA 2 - 2-10 SOUTH SHEETPILE AREA
SOIL (0-11 FEET) AND
GROUNDWATER EXCEEDANCE AREAS

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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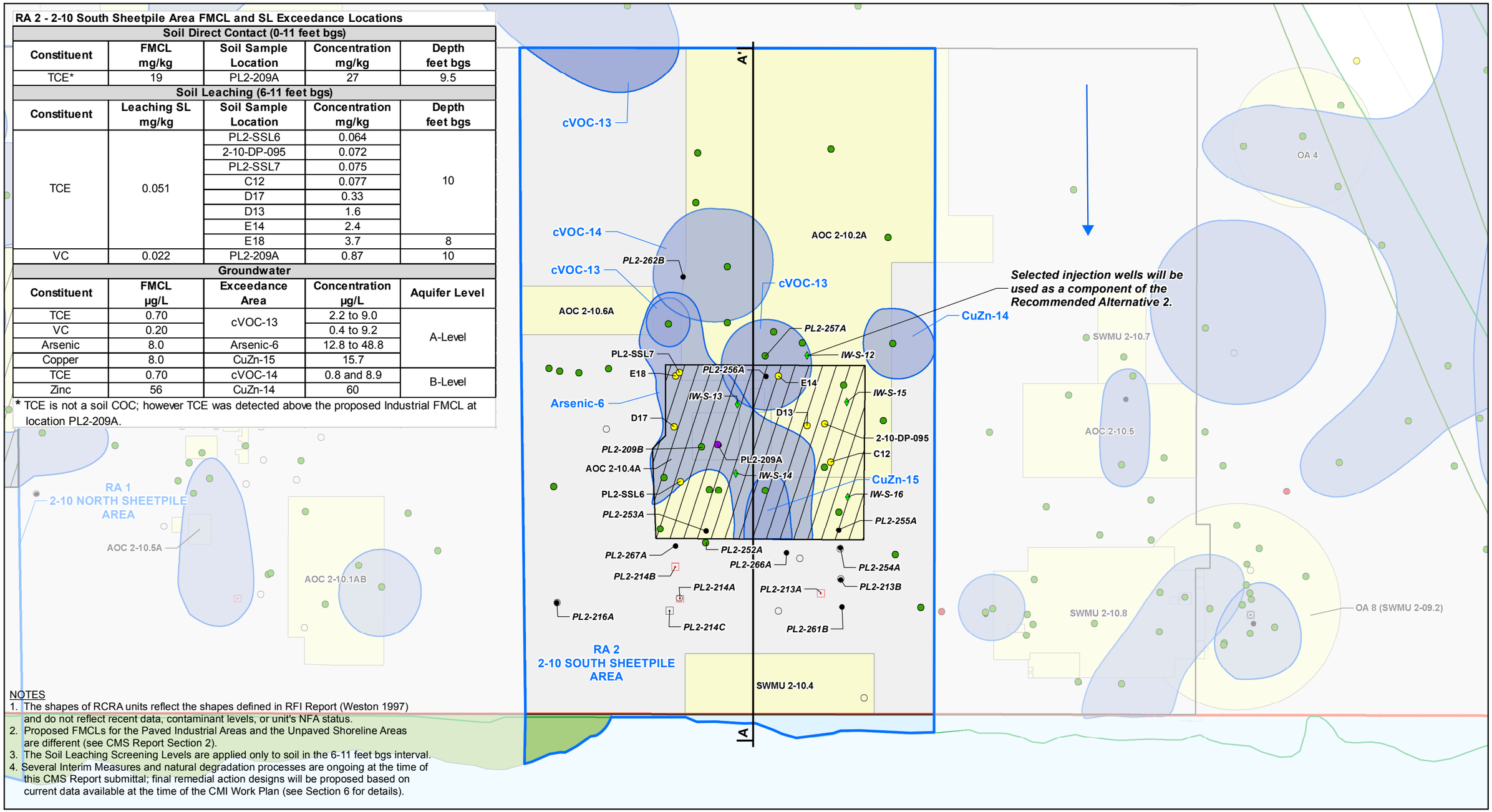
Golder Associates

RA 2 - 2-10 South Sheetpile Area FMCL and SL Exceedance Locations

Soil Direct Contact (0-11 feet bgs)				
Constituent	**FMCL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
TCE*	19	PL2-209A	27	9.5
Soil Leaching (6-11 feet bgs)				
Constituent	**Leaching SL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
TCE	0.051	PL2-SSL6	0.064	10
		2-10-DP-095	0.072	
		PL2-SSL7	0.075	
		C12	0.077	
		D17	0.33	
		D13	1.6	
		E14	2.4	
		E18	3.7	8
VC	0.022	PL2-209A	0.87	10
Groundwater				
Constituent	**FMCL µg/L**	**Exceedance Area**	**Concentration µg/L**	**Aquifer Level**
TCE	0.70	cVOC-13	2.2 to 9.0	A-Level
VC	0.20		0.4 to 9.2	
Arsenic	8.0	Arsenic-6	12.8 to 48.8	
Copper	8.0	CuZn-15	15.7	
TCE	0.70	cVOC-14	0.8 and 8.9	B-Level
Zinc	56	CuZn-14	60	

* TCE is not a soil COC; however TCE was detected above the proposed Industrial FMCL at location PL2-209A.



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. The Soil Leaching Screening Levels are applied only to soil in the 6-11 feet bgs interval.
4. Several Interim Measures and natural degradation processes are ongoing at the time of this CMS Report submittal; final remedial action designs will be proposed based on current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC

Wells
- Current EMF Well
- Current Shoreline Monitoring Well
- Current Shoreline Monitoring Well Not Proposed for Future Shoreline Monitoring
- Other Existing Well
- Proposed New Shoreline Monitoring Well
- Proposed Ongoing ERD Injection Well
- Proposed Property Boundary Monitoring Well
- Proposed Upgradient Monitoring Well

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)
- Groundwater Flow Direction
- Cross Section A to A'
- Remediation Area
- Groundwater Exceedance Area

Risk Management Areas
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Southwest Bank Corrective Measure Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 60
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

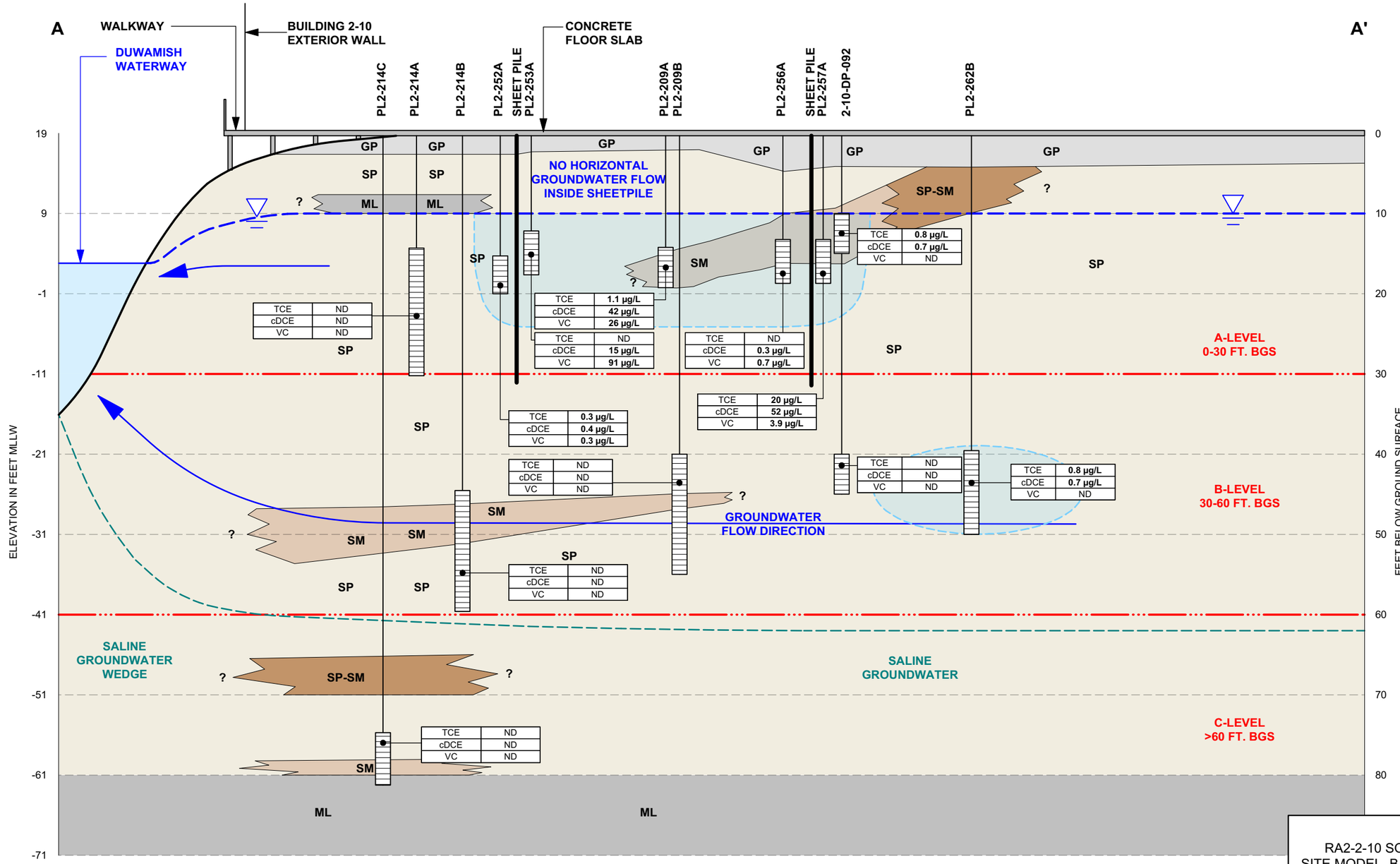
N

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **6-4B**
BOEING PLANT 2
RA 2 - 2-10 SOUTH SHEETPILE AREA
RECOMMENDED ALTERNATIVE 2
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

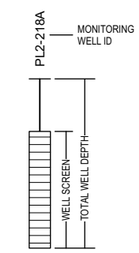
Path: G:\Boeing\Plant 2\99_PROJECTS\0131646017_CMS_CONSTRUCTION_SUPPORT\100_CMS_SOB_CMI\02_PRODUCTION\MXD\FIGURES\CMS_Report\Rev0\0131646017_100_058_F_6_4B_Rev0_2_10_SouthSheetpileAndSurroundingAreaRA2.mxd Date: 10/31/2017 User: HJackson

Golder Associates



NOTES:

GP	POORLY-GRADED GRAVEL
SM	SILTY SAND
SP	POORLY-GRADED SAND
ML	SILT
SP-SM	POORLY-GRADED SAND WITH SILT
TCE	TRICHLOROETHENE
cDCE	CIS-1,2-DICHLOROETHENE
VC	VINYL CHLORIDE
ND	NOT DETECTED
NS	NOT SAMPLED
µg/L	MICROGRAMS PER LITER
	GROUNDWATER LEVEL
	GROUNDWATER FLOW DIRECTION
	<1,000 µg/L FMCL EXCEEDANCE AREA



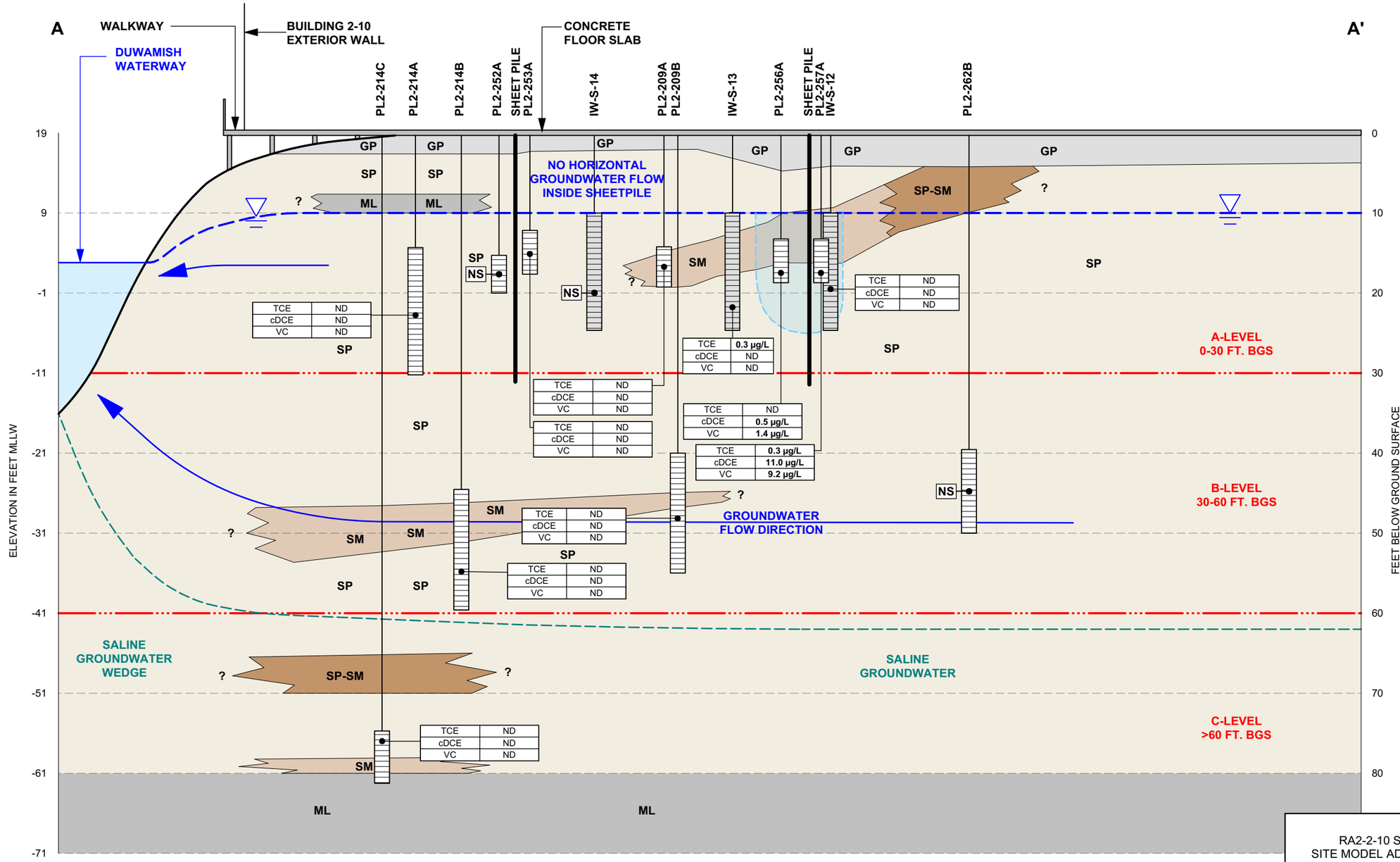
0 10 20 40

SCALE: 1" = 40'
3X VERTICAL EXAGGERATION

FIGURE 6-4C

RA2-2-10 SOUTH SHEETPILE AREA CONCEPTUAL SITE MODEL BASED ON DATA THROUGH JANUARY 2013

PREPARED BY	ENVIRONMENTAL PARTNERS INC		
REPORT	CMS VOLUME X		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILLA WASHINGTON		
PREPARED FOR	THE BOEING COMPANY		
DATE 10/23/17	DRAWN BY VPB	REVIEWED BY DCK	PROJECT NUMBER 17517.0.100.01



NOTES:

GP	POORLY-GRADED GRAVEL
SM	SILTY SAND
SP	POORLY-GRADED SAND
ML	SILT
SP-SM	POORLY-GRADED SAND WITH SILT
TCE	TRICHLOROETHENE
cDCE	CIS-1,2-DICHLOROETHENE
VC	VINYL CHLORIDE
ND	NOT DETECTED
NS	NOT SAMPLED
µg/L	MICROGRAMS PER LITER
	GROUNDWATER LEVEL
	GROUNDWATER FLOW DIRECTION
	<1,000 µg/L FMCL EXCEEDANCE AREA

PL2-218A — MONITORING WELL ID; WELL SCREEN; TOTAL WELL DEPTH

IW-N-14 — INJECTION WELL ID; WELL SCREEN; TOTAL WELL DEPTH

0 10 20 40

SCALE: 1" = 40'
3X VERTICAL EXAGGERATION

FIGURE 6-4D
RA2-2-10 SOUTH SHEETPILE AREA CONCEPTUAL SITE MODEL ADJUSTED WITH DATA THROUGH DECEMBER 2016 WHERE APPLICABLE

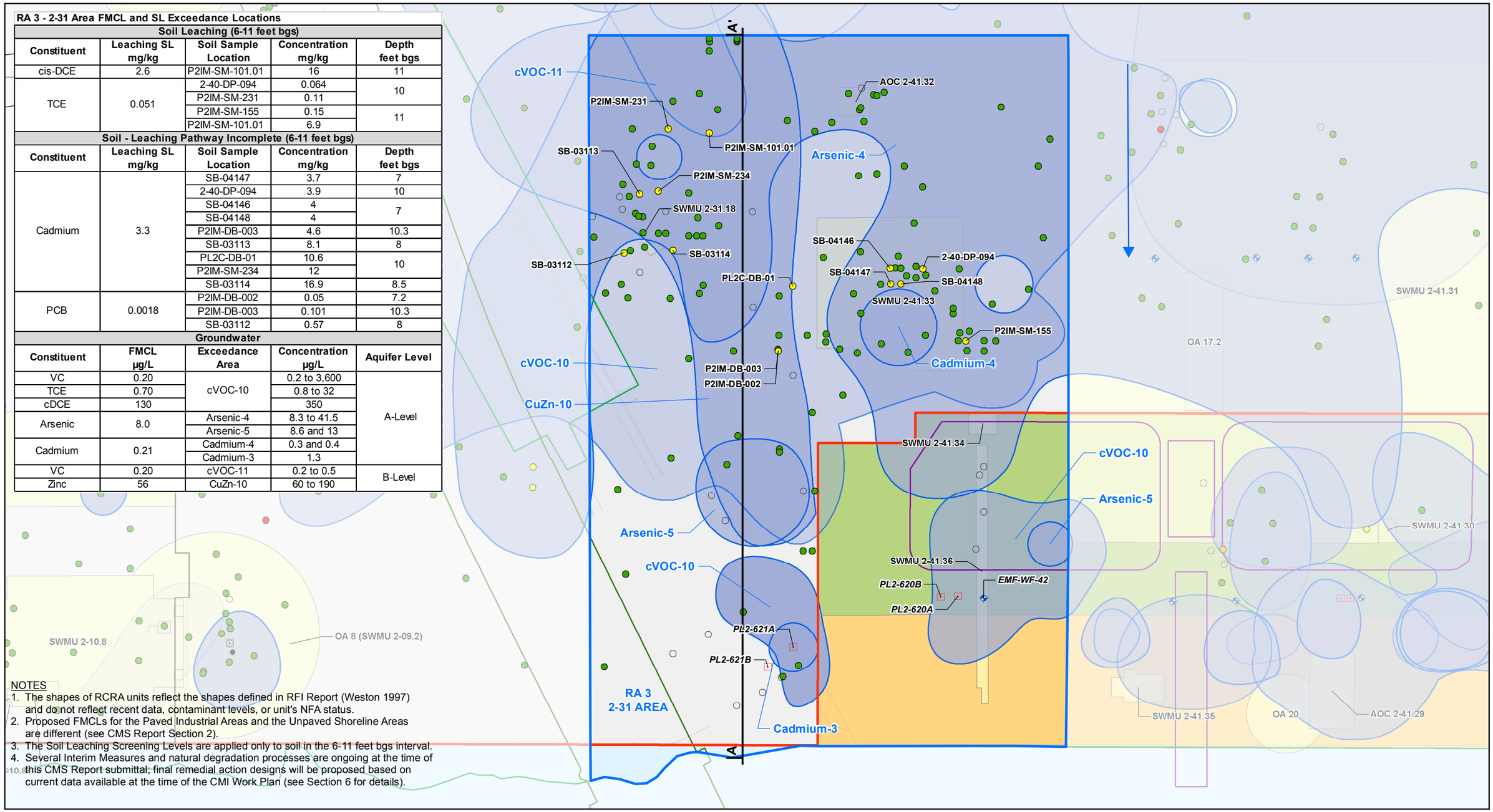
PREPARED BY	ENVIRONMENTAL PARTNERS INC		
REPORT	CMS VOLUME X		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILLA WASHINGTON		
PREPARED FOR	THE BOEING COMPANY		
DATE 10/13/17	DRAWN BY VPB	REVIEWED BY DCK	PROJECT NUMBER 17517.0.100.01

RA 3 - 2-31 Area FMCL and SL Exceedance Locations

Soil Leaching (6-11 feet bgs)				
Constituent	**Leaching SL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
cis-DCE	2.6	P2IM-SM-101.01	16	11
TCE	0.051	2-40-DP-094	0.064	10
		P2IM-SM-231	0.11	
		P2IM-SM-155	0.15	11
		P2IM-SM-101.01	6.9	

Soil - Leaching Pathway Incomplete (6-11 feet bgs)				
Constituent	**Leaching SL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
Cadmium	3.3	SB-04147	3.7	7
		2-40-DP-094	3.9	10
		SB-04146	4	7
		SB-04148	4	
		P2IM-DB-003	4.6	10.3
		SB-03113	8.1	8
		PL2C-DB-01	10.6	10
		P2IM-SM-234	12	
		SB-03114	16.9	8.5
PCB	0.0018	P2IM-DB-002	0.05	7.2
		P2IM-DB-003	0.101	10.3
		SB-03112	0.57	8

Groundwater				
Constituent	**FMCL µg/L**	**Exceedance Area**	**Concentration µg/L**	**Aquifer Level**
VC	0.20	cVOC-10	0.2 to 3,600	A-Level
TCE	0.70		0.8 to 32	
cDCE	130		350	
Arsenic	8.0	Arsenic-4	8.3 to 41.5	
		Arsenic-5	8.6 and 13	
Cadmium	0.21	Cadmium-4	0.3 and 0.4	
		Cadmium-3	1.3	
VC	0.20	cVOC-11	0.2 to 0.5	B-Level
Zinc	56	CuZn-10	60 to 190	



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. The Soil Leaching Screening Levels are applied only to soil in the 6-11 feet bgs interval.
4. Several Interim Measures and natural degradation processes are ongoing at the time of this CMS Report submittal; final remedial action designs will be proposed based on current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Wells
- Current EMF Well
- Current Shoreline Monitoring Well
- Current Shoreline Monitoring Well Not Proposed for Future Shoreline Monitoring
- Other Existing Well
- Proposed New Shoreline Monitoring Well
- Proposed Property Boundary Monitoring Well
- Proposed Upgradient Monitoring Well
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)
- Groundwater Flow Direction
- Cross Section A to A'
- Remediation Area
- Groundwater Exceedance Area

Risk Management Areas
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Southwest Bank Corrective Measure Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 60
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **6-5A**

BOEING PLANT 2
RA 3 - 2-31 AREA
SOIL (0-11 FEET) AND
GROUNDWATER EXCEEDANCE AREAS

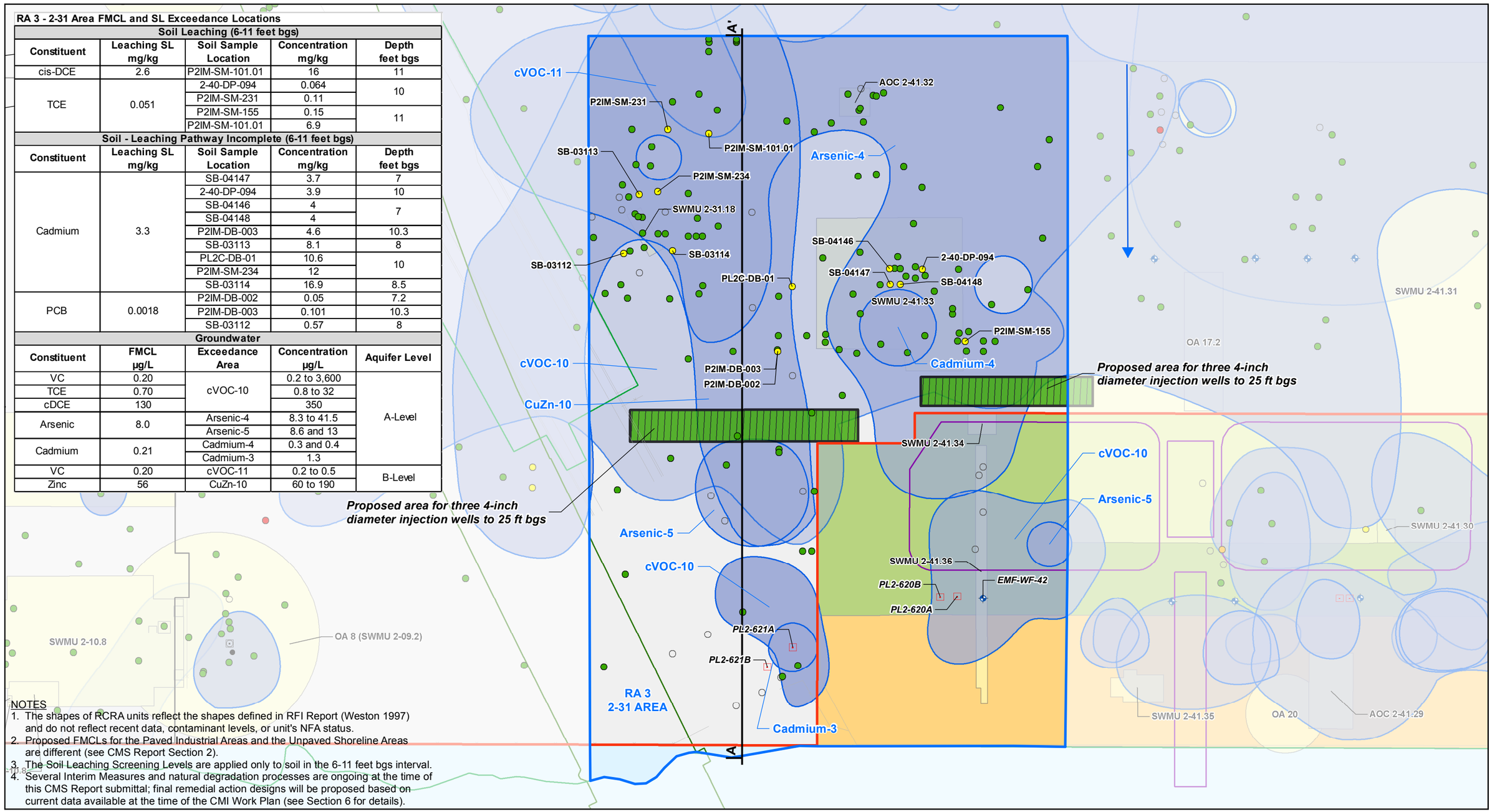
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

Path: G:\Boeing\Plant 2\99_PROJECTS\0131646017_CMS_CONSTRUCTION_SUPPORT\100_CMS_SOB_CMI\02_PRODUCTION\MXD\FIGURES\CMS_Report\Rev0\0131646017_100_059_F_6_5A_Rev0_2_31_AreaSoil_RA3.mxd Date: 10/31/2017 User: HJackson

Golder Associates

RA 3 - 2-31 Area FMCL and SL Exceedance Locations

Constituent	Leaching SL mg/kg	Soil Sample Location	Concentration mg/kg	Depth feet bgs
Soil Leaching (6-11 feet bgs)				
cis-DCE	2.6	P2IM-SM-101.01	16	11
TCE	0.051	2-40-DP-094	0.064	10
		P2IM-SM-231	0.11	
		P2IM-SM-155	0.15	11
		P2IM-SM-101.01	6.9	
Soil - Leaching Pathway Incomplete (6-11 feet bgs)				
Cadmium	3.3	SB-04147	3.7	7
		2-40-DP-094	3.9	10
		SB-04146	4	7
		SB-04148	4	
		P2IM-DB-003	4.6	10.3
		SB-03113	8.1	8
		PL2C-DB-01	10.6	10
		P2IM-SM-234	12	
		SB-03114	16.9	8.5
PCB	0.0018	P2IM-DB-002	0.05	7.2
		P2IM-DB-003	0.101	10.3
		SB-03112	0.57	8
Groundwater				
Constituent	**FMCL µg/L**	**Exceedance Area**	**Concentration µg/L**	**Aquifer Level**
VC	0.20	cVOC-10	0.2 to 3,600	A-Level
TCE	0.70		0.8 to 32	
cDCE	130		350	
Arsenic	8.0	Arsenic-4	8.3 to 41.5	
		Arsenic-5	8.6 and 13	
Cadmium	0.21	Cadmium-4	0.3 and 0.4	
		Cadmium-3	1.3	
VC	0.20	cVOC-11	0.2 to 0.5	B-Level
Zinc	56	CuZn-10	60 to 190	



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. The Soil Leaching Screening Levels are applied only to soil in the 6-11 feet bgs interval.
4. Several Interim Measures and natural degradation processes are ongoing at the time of this CMS Report submittal; final remedial action designs will be proposed based on current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Wells
- Current EMF Well
- Current Shoreline Monitoring Well
- Current Shoreline Monitoring Well Not Proposed for Future Shoreline Monitoring
- Other Existing Well
- Proposed New Shoreline Monitoring Well
- Proposed Ongoing ERD Injection Well
- Proposed Property Boundary Monitoring Well
- Proposed Upgradient Monitoring Well
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)
- Groundwater Flow Direction
- Cross Section A to A'
- Remediation Area
- Groundwater Exceedance Area
- Proposed Area for Injection Wells

Risk Management Areas
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Southwest Bank Corrective Measure Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 60
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **6-5B**
BOEING PLANT 2
RA 3 - 2-31 AREA
RECOMMENDED ALTERNATIVE 2
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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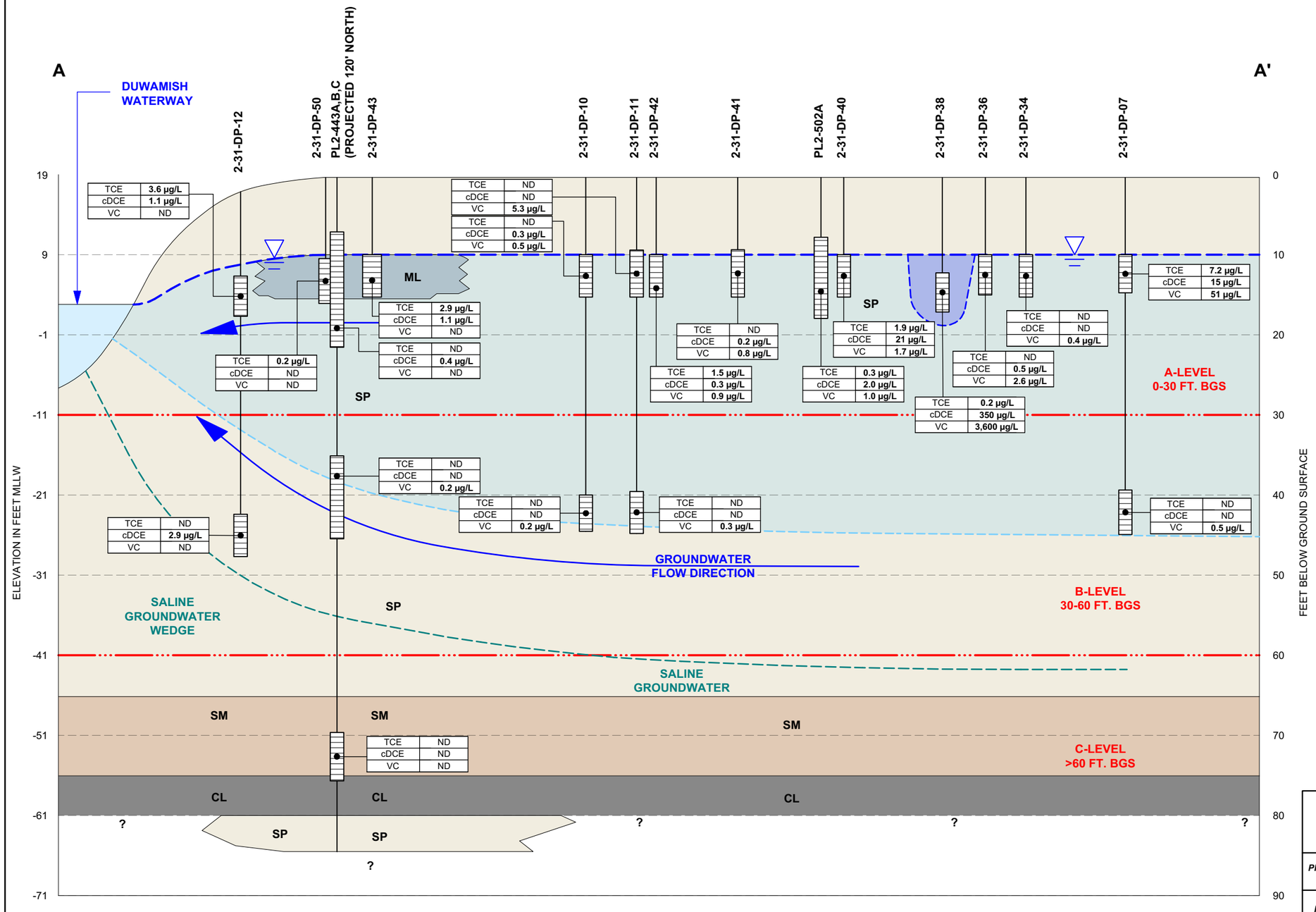
Golder Associates



NOTES:

SM	SILTY SAND
SP	POORLY-GRADED SAND
ML	SILT
CL	CLAY OF LOW PLASTICITY, LEAN CLAY
TCE	TRICHLOROETHENE
cDCE	CIS-1,2-DICHLOROETHENE
VC	VINYL CHLORIDE
ND	NOT DETECTED
NS	NOT SAMPLED
µg/L	MICROGRAMS PER LITER
	GROUNDWATER LEVEL
	GROUNDWATER FLOW DIRECTION
	<1,000 µg/L FMCL EXCEEDANCE AREA
	>1,000 µg/L FMCL EXCEEDANCE AREA

PL2-218A — MONITORING WELL ID
WELL SCREEN
TOTAL WELL DEPTH

0 10 20 40

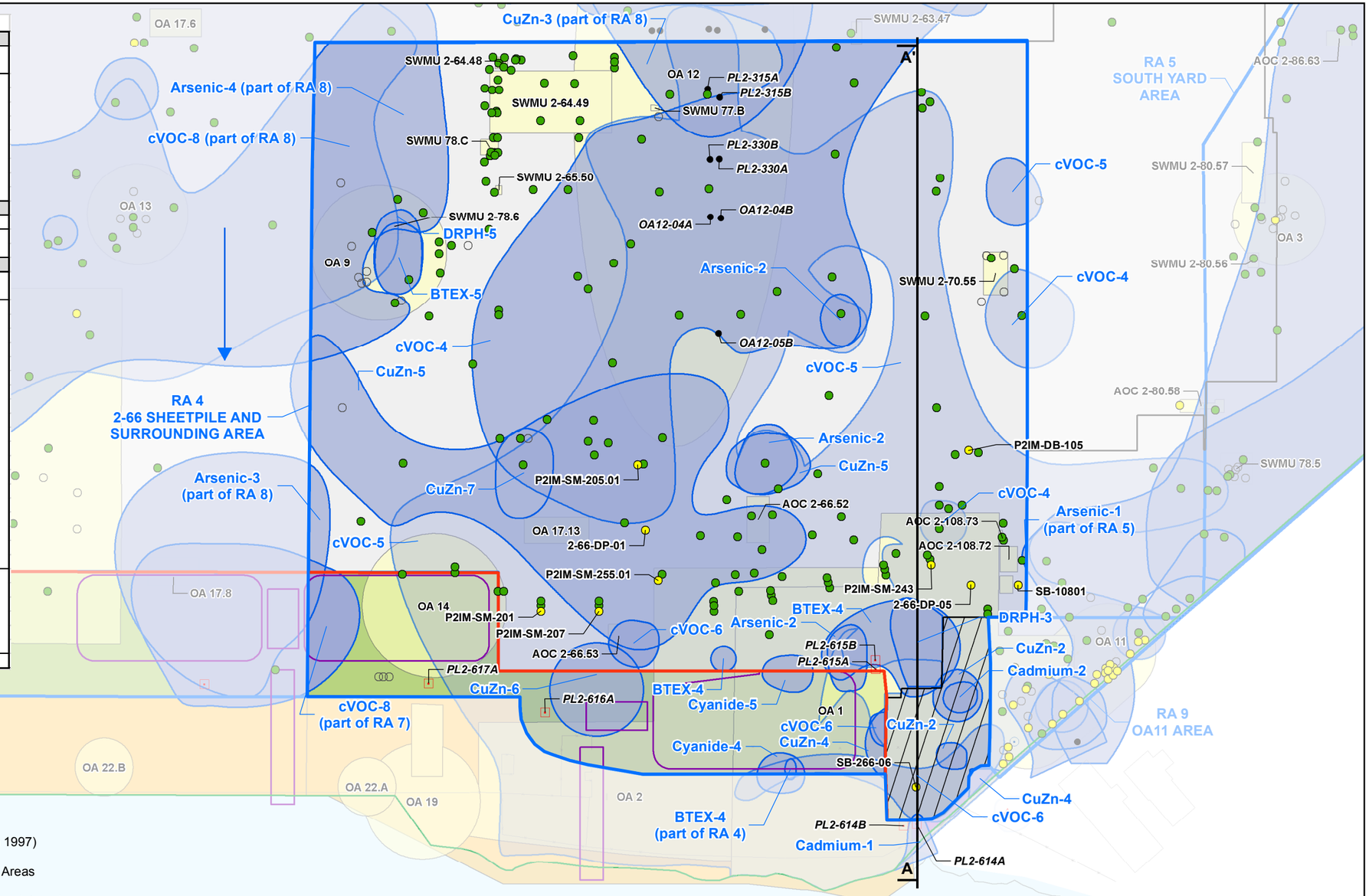
SCALE: 1" = 40'
3X VERTICAL EXAGGERATION

FIGURE 6-5C
RA3 2-31 AREA CONCEPTUAL SITE MODEL
BASED ON DATA THROUGH JANUARY 2013

PREPARED BY	ENVIRONMENTAL PARTNERS INC		
REPORT	CMS VOLUME X		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILLA WASHINGTON		
PREPARED FOR	THE BOEING COMPANY		
DATE 10/23/17	***DRAWN BY*** VPB	***REVIEWED BY*** DCK	***PROJECT NUMBER*** 17517.0.100.01

RA 4 - 2-66 Sheetpile and Surrounding Area FMCL and SL Exceedance Locations

Constituent	Leaching SL mg/kg	Soil Sample Location	Concentration mg/kg	Depth feet bgs
Soil Leaching (6-11 feet bgs)				
TCE	0.051	P2IM-SM-201	0.06	10
		2-66-DP-01	0.083	
		P2IM-SM-243	0.1	
		2-66-DP-05	0.12	
		P2IM-SM-205.01	0.12	
		SB-10801	0.14	
		P2IM-SM-255.01	0.16	
		P2IM-SM-207	0.19	
		SB-266-06	0.82	
Soil - Leaching Pathway Incomplete (6-11 feet bgs)				
PCB	0.0018	P2IM-DB-105	0.083	8
		P2IM-SM-207	0.164	10
cPAH	0.057	2-66-DP-05	0.1158	
Groundwater				
Constituent	**FMCL µg/L**	**Exceedance Area**	**Concentration µg/L**	**Aquifer Level**
TCE	0.70	cVOC-5	1.0 to 1,100	A-Level
VC	0.20		0.2 to 900	
cDCE	130		312 to 870	
Benzene	1.6	BTEX-4	8.7 and 10	
		BTEX-5	39 and 180	
Ethylbenzene	1.7	BTEX-4	2.6 to 13	
		BTEX-5	160 and 200	
GRPH	Note 5	BTEX-4	1,100	
		BTEX-5	4,800 and 6,200	
Arsenic	8.0	Arsenic-2	9.6 to 18.4	
Copper	8.0	CuZn-5	8.3 to 74.6	
Zinc	56	CuZn-2	219 to 305	
		CuZn-5	583	
Cyanide	1.0	Cyanide-5	5	
DRPH	Note 5	DRPH-3	1,300 and 11,000	
MoRPH	Note 5		5,000	
Naphthalene	26	DRPH-5	300 to 630	
Cadmium	0.21	Cadmium-2	0.3	
		Cadmium-1	0.95	
VC	0.20	cVOC-4	0.2 to 15.9	B-Level
		cVOC-6	0.3 to 4.7	
TCE	0.70		0.9 and 5.0	
Zinc	56	CuZn-4	166 and 548	
		CuZn-7	66	
Cyanide	1.0	Cyanide-4	6	
Copper	8.0	CuZn-6	14	C-Level



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. The Soil Leaching Screening Levels are applied only to soil in the 6-11 feet bgs interval.
4. Several Interim Measures and natural degradation processes are ongoing at the time of this CMS Report submittal; final remedial action designs will be proposed based on current data available at the time of the CMI Work Plan (see Section 6 for details).
5. TPH exceedance areas are drawn based on TMCLs; the FMCLs are based on the BTEX and naphthalene constituents (see Section 2 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC

Wells
- Current EMF Well
- Current Shoreline Monitoring Well
- Current Shoreline Monitoring Well Not Proposed for Future Shoreline Monitoring
- Other Existing Well
- Proposed New Shoreline Monitoring Well
- Proposed Property Boundary Monitoring Well
- Proposed Upgradient Monitoring Well
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)
- Groundwater Flow Direction
- Cross Section A to A'
- Remediation Area
- Groundwater Exceedance Area

Risk Management Areas
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Southwest Bank Corrective Measure Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 100
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **6-6A**

BOEING PLANT 2 RA 4 - 2-66 SHEETPILE AND SURROUNDING AREA SOIL (0-11 FEET) AND GROUNDWATER EXCEEDANCE AREAS

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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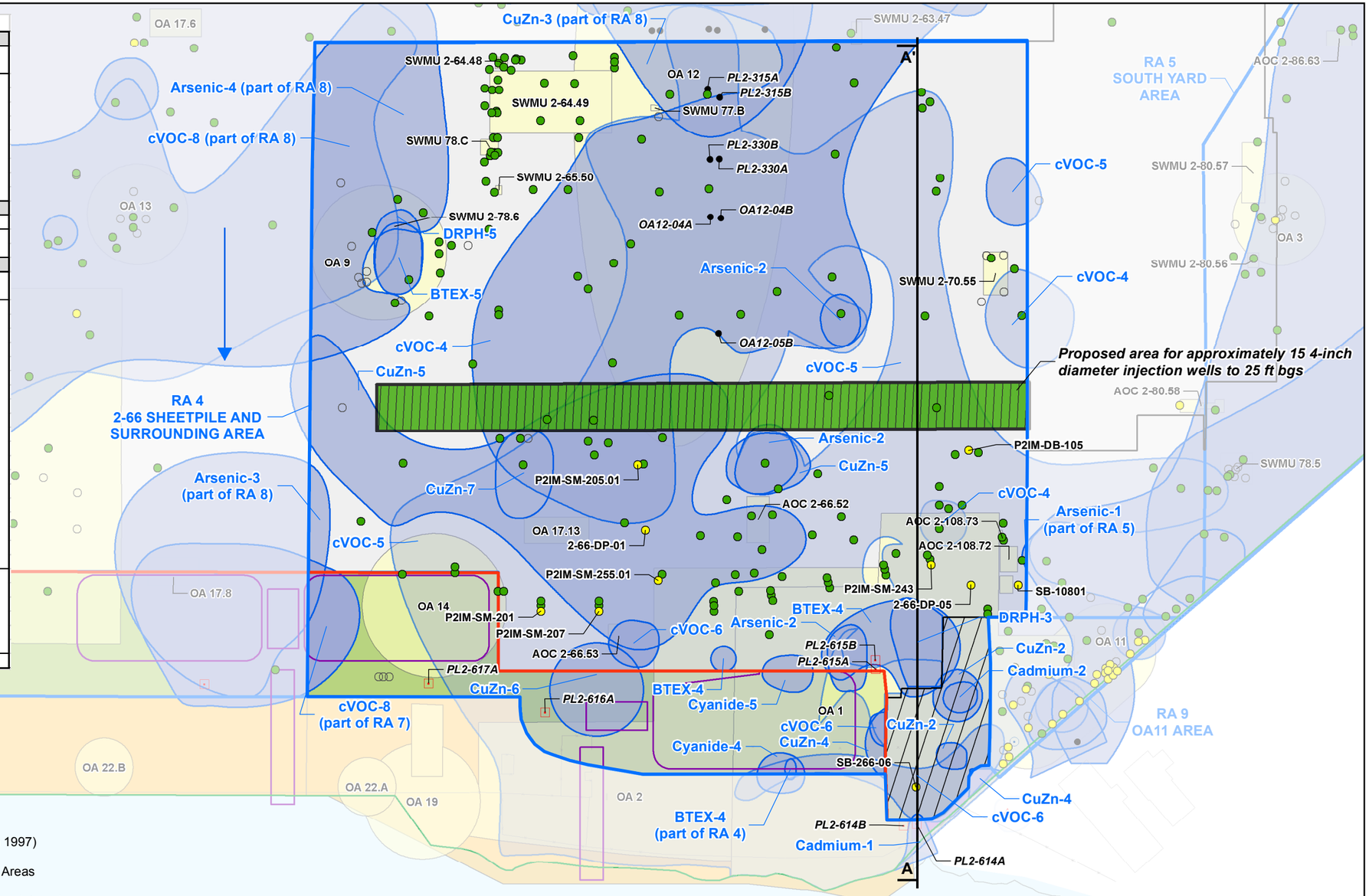
Golder Associates

RA 4 - 2-66 Sheetpile and Surrounding Area FMCL and SL Exceedance Locations

Constituent	Leaching SL mg/kg	Soil Sample Location	Concentration mg/kg	Depth feet bgs
Soil Leaching (6-11 feet bgs)				
TCE	0.051	P2IM-SM-201	0.06	10
		2-66-DP-01	0.083	
		P2IM-SM-243	0.1	
		2-66-DP-05	0.12	
		P2IM-SM-205.01	0.12	
		SB-10801	0.14	
		P2IM-SM-255.01	0.16	
		P2IM-SM-207	0.19	
		SB-266-06	0.82	
Soil - Leaching Pathway Incomplete (6-11 feet bgs)				
PCB	0.0018	P2IM-DB-105	0.083	8
		P2IM-SM-207	0.164	10
cPAH	0.057	2-66-DP-05	0.1158	

Constituent	FMCL µg/L	Exceedance Area	Concentration µg/L	Aquifer Level
Groundwater				
TCE	0.70	cVOC-5	1.0 to 1,100	A-Level
VC	0.20		0.2 to 900	
cDCE	130		312 to 870	
Benzene	1.6	BTEX-4	8.7 and 10	
		BTEX-5	39 and 180	
Ethylbenzene	1.7	BTEX-4	2.6 to 13	
		BTEX-5	160 and 200	
GRPH	Note 5	BTEX-4	1,100	
		BTEX-5	4,800 and 6,200	
Arsenic	8.0	Arsenic-2	9.6 to 18.4	
Copper	8.0	CuZn-5	8.3 to 74.6	
Zinc	56	CuZn-2	219 to 305	
		CuZn-5	583	
Cyanide	1.0	Cyanide-5	5	
DRPH	Note 5	DRPH-3	1,300 and 11,000	
MoRPH	Note 5		5,000	
Naphthalene	26	DRPH-5	300 to 630	
Cadmium	0.21	Cadmium-2	0.3	
		Cadmium-1	0.95	
VC	0.20	cVOC-4	0.2 to 15.9	B-Level
		cVOC-6	0.3 to 4.7	
TCE	0.70		0.9 and 5.0	
Zinc	56	CuZn-4	166 and 548	
		CuZn-7	66	
Cyanide	1.0	Cyanide-4	6	
Copper	8.0	CuZn-6	14	C-Level



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. The Soil Leaching Screening Levels are applied only to soil in the 6-11 feet bgs interval.
4. Several Interim Measures and natural degradation processes are ongoing at the time of this CMS Report submittal; final remedial action designs will be proposed based on current data available at the time of the CMI Work Plan (see Section 6 for details).
5. TPH exceedance areas are drawn based on TMCLs; the FMCLs are based on the BTEX and naphthalene constituents (see Section 2 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC

Wells
- Current EMF Well
- Current Shoreline Monitoring Well
- Current Shoreline Monitoring Well Not Proposed for Future Shoreline Monitoring
- Other Existing Well
- Proposed New Shoreline Monitoring Well
- Proposed Ongoing ERD Injection Well
- Proposed Property Boundary Monitoring Well
- Proposed Upgradient Monitoring Well
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)
- Groundwater Flow Direction
- Cross Section A to A'
- Remediation Area
- Groundwater Exceedance Area
- Proposed Area for Injection Well

Risk Management Areas
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Southwest Bank Corrective Measure Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 100
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **6-6B**

BOEING PLANT 2 RA 4 - 2-66 SHEETPILE AND SURROUNDING AREA RECOMMENDED ALTERNATIVE 2

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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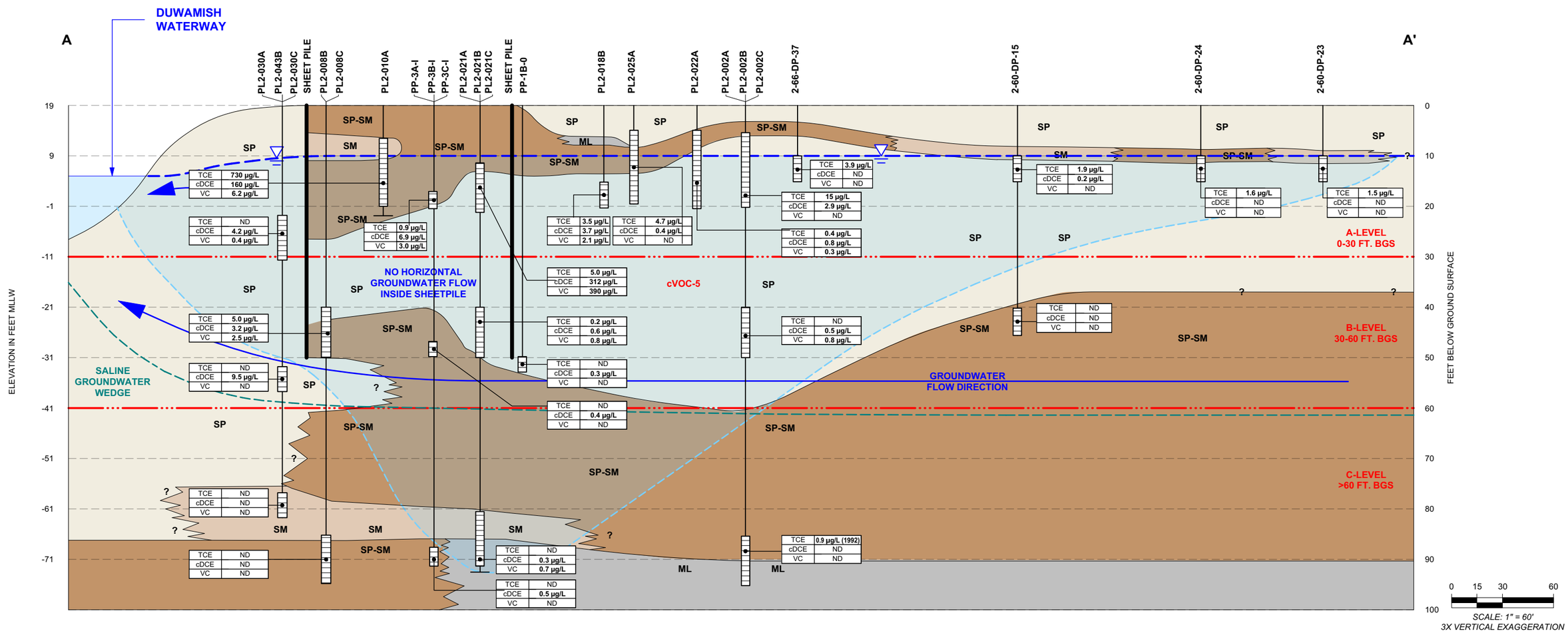
Golder Associates



NOTES:

SM	SILTY SAND
SP	POORLY-GRADED SAND
ML	SILT
SP-SM	POORLY-GRADED SAND WITH SILT
TCE	TRICHLOROETHENE
cDCE	CIS-1,2-DICHLOROETHENE
VC	VINYL CHLORIDE
ND	NOT DETECTED
NS	NOT SAMPLED
µg/L	MICROGRAMS PER LITER

GROUNDWATER LEVEL

GROUNDWATER FLOW DIRECTION

<1,000 µg/L FMCL EXCEEDANCE AREA

PL2-218A — MONITORING WELL ID

WELL SCREEN

TOTAL WELL DEPTH

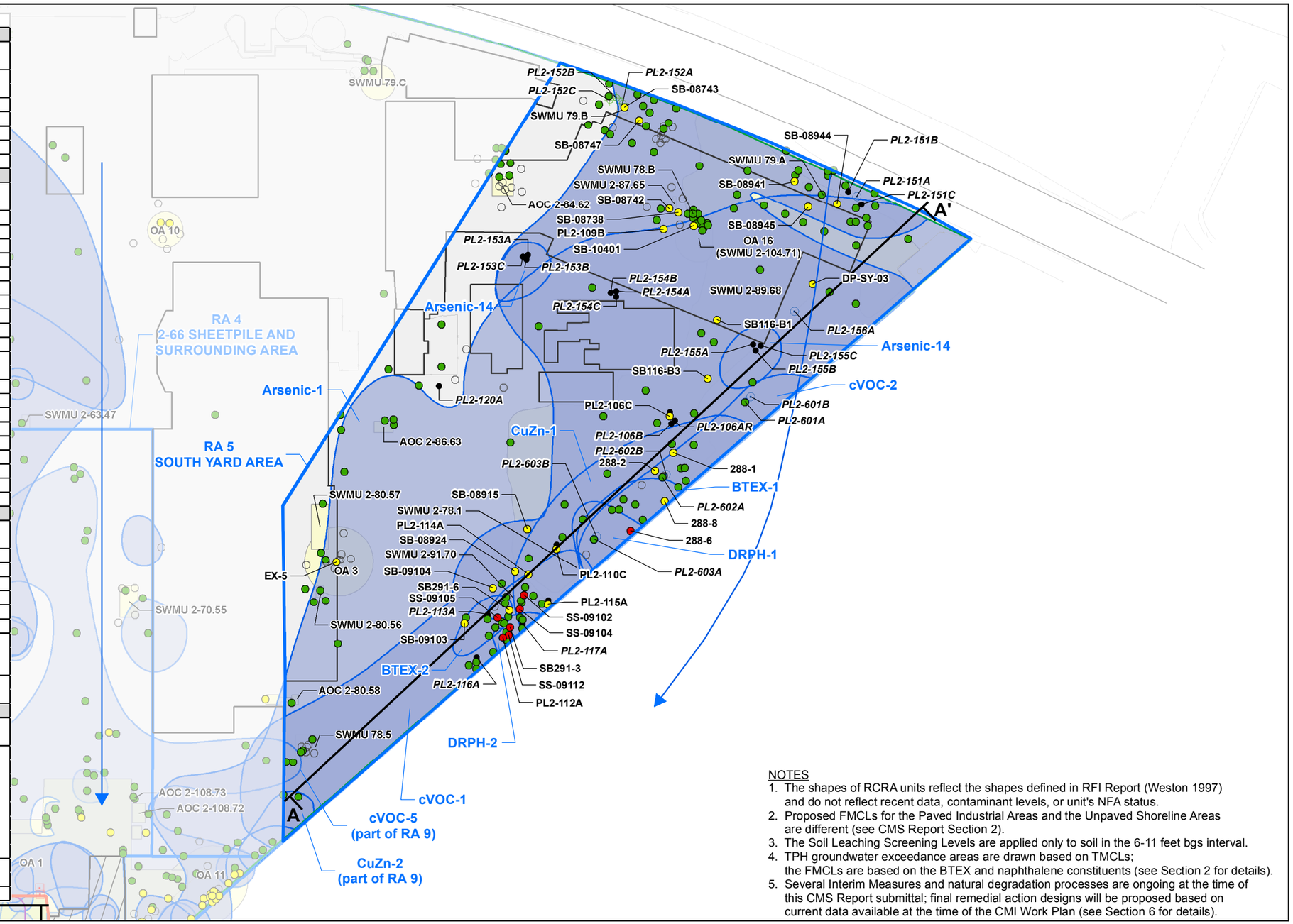
FIGURE 6-6C

RA 4 2-66 SHEETPILE AND SURROUNDING AREA CONCEPTUAL SITE MODEL BASED ON DATA THROUGH JANUARY 2013

PREPARED BY	ENVIRONMENTAL PARTNERS INC		
REPORT	CMS VOLUME X		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILLA WASHINGTON		
PREPARED FOR	THE BOEING COMPANY		
DATE 10/23/17	DRAWN BY VPB	REVIEWED BY DCK	PROJECT NUMBER 17517.0.100.01

RA 5 - South Yard Area FMCL and SL Exceedance Locations

Constituent	FMCL mg/kg	Soil Sample Location	Concentration mg/kg	Depth feet bgs
Soil Direct Contact (0-11 feet bgs)				
PCBs	10	SS-09105	211.9	0.5
MoRPH	17,000	SS-09102	21,000	
		288-6	27,000	3
		SS-09112	34,000	0.5
		PL2-112A	51,665	5.5
		SS-09104	54,000	0.5
		SB291-3	56,827	5
Soil Leaching (6-11 feet bgs)				
Constituent	**Leaching SL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
TCE	0.051	SB-08941	0.053	8
		SB116-B3	0.084	7
		SB-09104	0.12	7.5
		SB116-B1	0.15	8
		SB291-6	0.2	7.5
		SB-08747	0.22	9
		SB-10401	0.22	10
		SB-08915	0.26	7.5
		PL2-109B	0.48	9
		PL2-106C	0.79	7
		288-8	1.2	8
		288-2	2.1	
VC	0.022	PL2-109B	0.032	9
		SB-08945	0.041	8
		SB-09103	0.046	7.5
		288-2	0.15	8
		PL2-115A	0.15	8.5
		288-8	0.16	8
		SB-09104	0.32	7.5
		288-1	1.1	8
DRPH	2,000	SB291-3	11,684	7.5
Soil - Leaching Pathway Incomplete (6-11 feet bgs)				
Constituent	**Leaching SL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
Ethylbenzene	0.23	EX-5	0.28	10.5
		SB-08924	0.53	7.5
		PL2-110C	0.81	9
		PL2-114A	1.6	8
Benzene	0.093	EX-5	0.28	10.5
Cadmium	3.3	SB-08944	61	11
PCB	0.0018	DP-SY-03	0.082	10
		SB-08742	0.17	
		SB-08738	0.335	
		SB-08743	0.513	11
Zinc	1,400	SB-08743	3,070	
Groundwater				
Constituent	**FMCL µg/L**	**Exceedance Area**	**Concentration µg/L**	**Aquifer Level**
VC	0.20	cVOC-1	0.6 to 31	A-Level
TCE	0.70		1.1 to 110	
Benzene	1.6	BTEX-2	5.3	
		BTEX-1	5.7	
Arsenic	8.0	Arsenic-1	8.2 to 99.8	
DRPH	See Note 4	DRPH-1	650	
		DRPH-2	8,900	
MoRPH			1,300	
VC	0.20	cVOC-2	3.1 to 12	B-Level
Zinc	56	CuZn-1	382 and 717	
Arsenic	8.0	Arsenic-14	9.0 and 16.0	C-Level



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. The Soil Leaching Screening Levels are applied only to soil in the 6-11 feet bgs interval.
4. TPH groundwater exceedance areas are drawn based on TMCLs; the FMCLs are based on the BTEX and naphthalene constituents (see Section 2 for details).
5. Several Interim Measures and natural degradation processes are ongoing at the time of this CMS Report submittal; final remedial action designs will be proposed based on current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC

Wells
- Current EMF Well
- Current Shoreline Monitoring Well
- Current Shoreline Monitoring Well Not Proposed for Future Shoreline Monitoring
- Other Existing Well
- Proposed New Shoreline Monitoring Well
- Proposed Property Boundary Monitoring Well
- Proposed Upgradient Monitoring Well
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)
- Groundwater Flow Direction
- Cross Section A to A'
- Remediation Area
- Groundwater Exceedance Area

Risk Management Areas
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Southwest Bank Corrective Measure Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 125
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **6-7A**

BOEING PLANT 2
RA 5 - SOUTH YARD AREA
SOIL (0-11 FEET) AND GROUNDWATER EXCEEDANCE AREAS

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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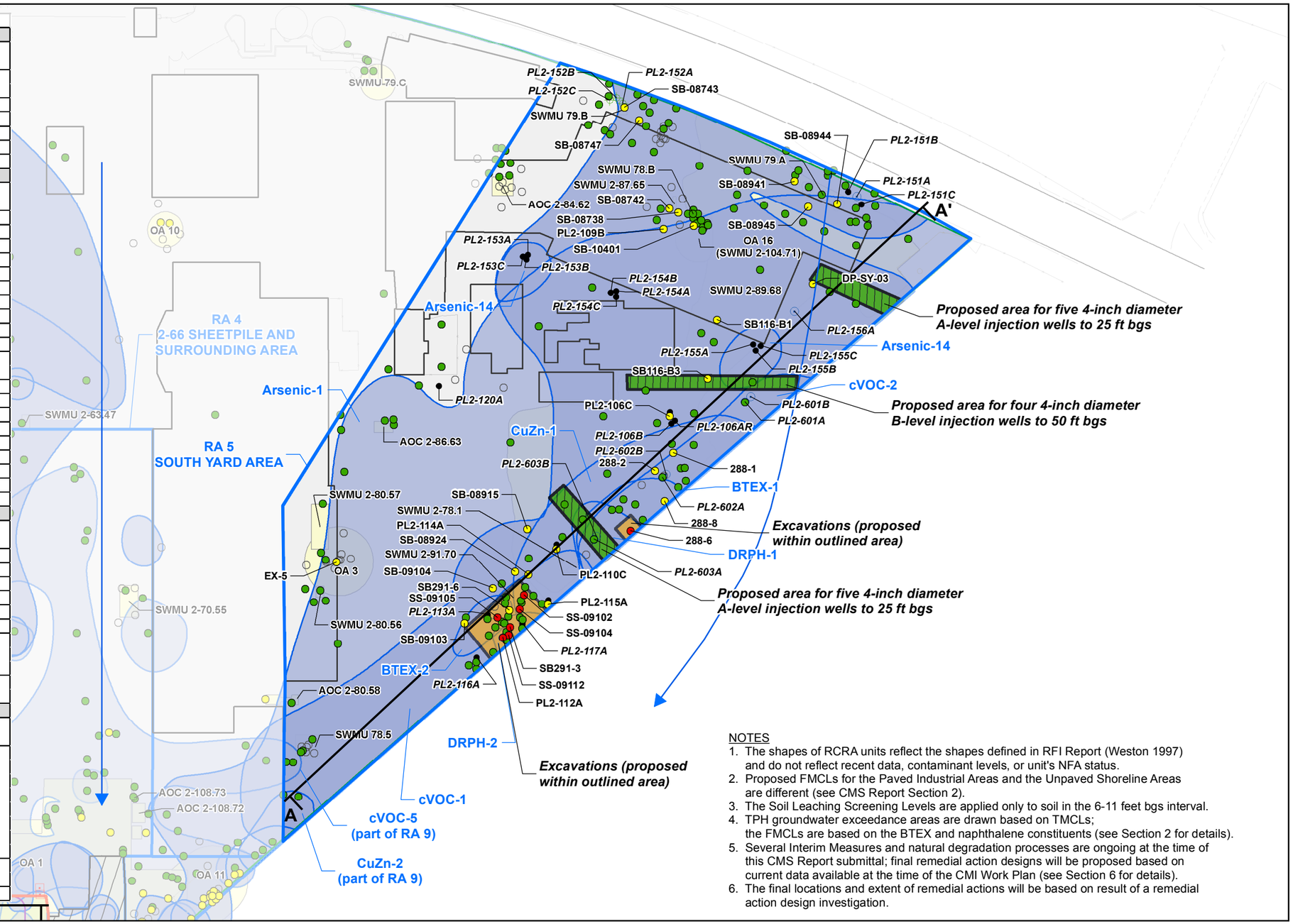
Golder Associates

RA 5 - South Yard Area FMCL and SL Exceedance Locations

Constituent	FMCL mg/kg	Soil Sample Location	Concentration mg/kg	Depth feet bgs
Soil Direct Contact (0-11 feet bgs)				
PCBs	10	SS-09105	211.9	0.5
MoRPH	17,000	SS-09102	21,000	
		288-6	27,000	3
		SS-09112	34,000	0.5
		PL2-112A	51,665	5.5
		SS-09104	54,000	0.5
		SB291-3	56,827	5
Soil Leaching (6-11 feet bgs)				
Constituent	**Leaching SL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
TCE	0.051	SB-08941	0.053	8
		SB116-B3	0.084	7
		SB-09104	0.12	7.5
		SB116-B1	0.15	8
		SB291-6	0.2	7.5
		SB-08747	0.22	9
		SB-10401	0.22	10
		SB-08915	0.26	7.5
		PL2-109B	0.48	9
		PL2-106C	0.79	7
		288-8	1.2	8
		288-2	2.1	
VC	0.022	PL2-109B	0.032	9
		SB-08945	0.041	8
		SB-09103	0.046	7.5
		288-2	0.15	8
		PL2-115A	0.15	8.5
		288-8	0.16	8
		SB-09104	0.32	7.5
		288-1	1.1	8
DRPH	2,000	SB291-3	11,684	7.5
Soil - Leaching Pathway Incomplete (6-11 feet bgs)				
Constituent	**Leaching SL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
Ethylbenzene	0.23	EX-5	0.28	10.5
		SB-08924	0.53	7.5
		PL2-110C	0.81	9
		PL2-114A	1.6	8
Benzene	0.093	EX-5	0.28	10.5
Cadmium	3.3	SB-08944	61	11
PCB	0.0018	DP-SY-03	0.082	10
		SB-08742	0.17	
		SB-08738	0.335	
		SB-08743	0.513	11
Zinc	1,400	SB-08743	3,070	
Groundwater				
Constituent	**FMCL µg/L**	**Exceedance Area**	**Concentration µg/L**	**Aquifer Level**
VC	0.20	cVOC-1	0.6 to 31	A-Level
TCE	0.70		1.1 to 110	
Benzene	1.6	BTEX-2	5.3	
		BTEX-1	5.7	
Arsenic	8.0	Arsenic-1	8.2 to 99.8	
DRPH	See Note 4	DRPH-1	650	
		DRPH-2	8,900	
MoRPH			1,300	
VC	0.20	cVOC-2	3.1 to 12	B-Level
Zinc	56	CuZn-1	382 and 717	
Arsenic	8.0	Arsenic-14	9.0 and 16.0	C-Level



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. The Soil Leaching Screening Levels are applied only to soil in the 6-11 feet bgs interval.
4. TPH groundwater exceedance areas are drawn based on TMCLs; the FMCLs are based on the BTEX and naphthalene constituents (see Section 2 for details).
5. Several Interim Measures and natural degradation processes are ongoing at the time of this CMS Report submittal; final remedial action designs will be proposed based on current data available at the time of the CMI Work Plan (see Section 6 for details).
6. The final locations and extent of remedial actions will be based on result of a remedial action design investigation.

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC

Wells
- Current EMF Well
- Current Shoreline Monitoring Well
- Current Shoreline Monitoring Well Not Proposed for Future Shoreline Monitoring
- Other Existing Well
- Proposed New Shoreline Monitoring Well
- Proposed Ongoing ERD Injection Well
- Proposed Property Boundary Monitoring Well
- Proposed Upgradient Monitoring Well
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Proposed Area for Injection Well
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)
- Groundwater Flow Direction
- Cross Section A to A'
- Remediation Area
- Groundwater Exceedance Area
- Planned Soil Excavation Area

Risk Management Areas
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Southwest Bank Corrective Measure Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 125
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **6-7B**
BOEING PLANT 2
RA 5 - SOUTH YARD AREA
RECOMMENDED ALTERNATIVE 2A
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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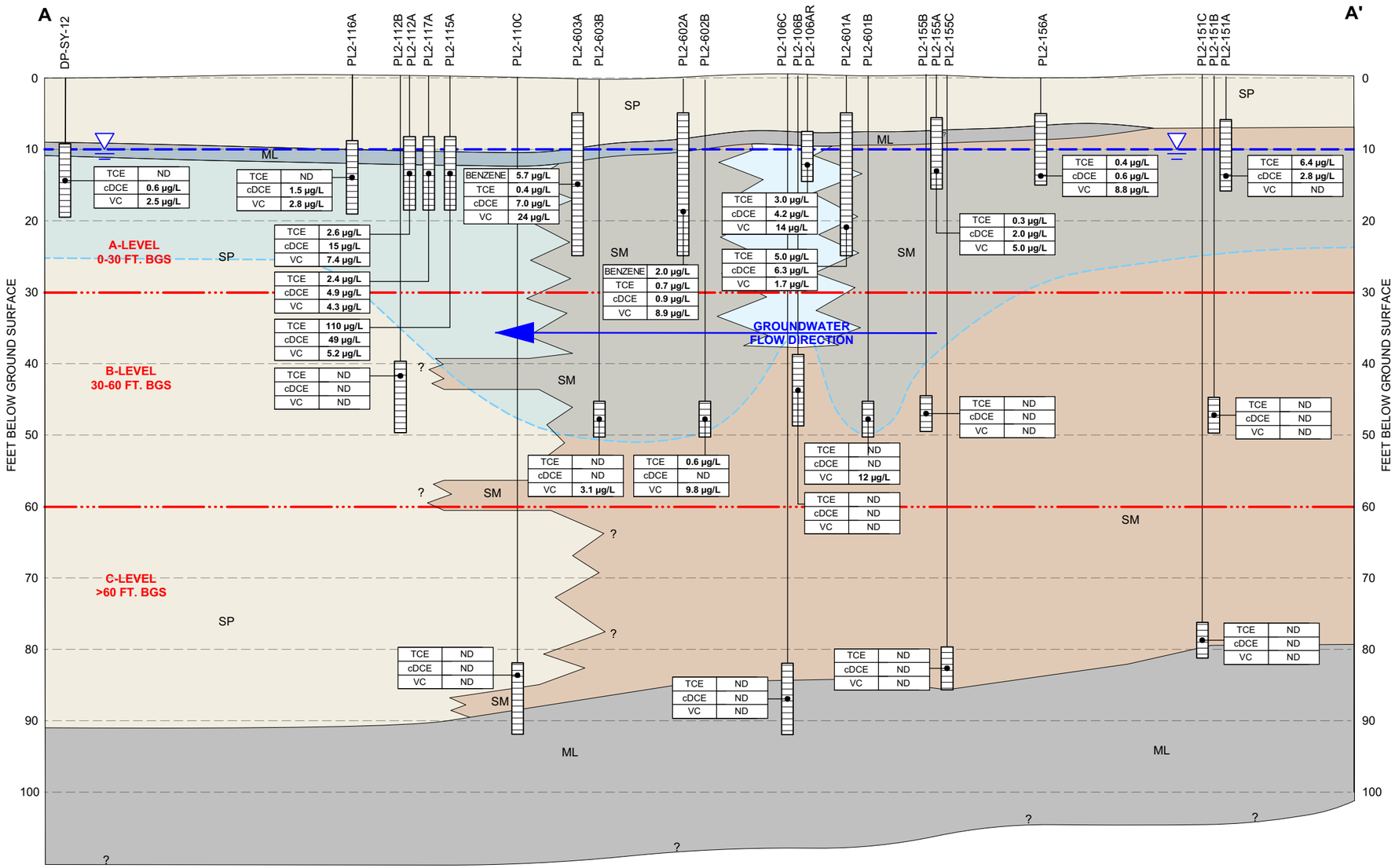
Golder Associates



NOTES:

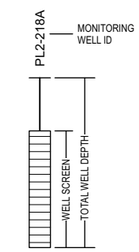
SM	SILTY SAND
SP	POORLY-GRADED SAND
ML	SILT
SP-SM	POORLY-GRADED SAND WITH SILT
TCE	TRICHLOROETHENE
cDCE	CIS-1,2-DICHLOROETHENE
VC	VINYL CHLORIDE
ND	NOT DETECTED
NS	NOT SAMPLED
µg/L	MICROGRAMS PER LITER

GROUNDWATER LEVEL

GROUNDWATER FLOW DIRECTION

>1,000 µg/L FMCL EXCEEDANCE AREA

<1,000 µg/L FMCL EXCEEDANCE AREA



0 25 50 100

SCALE: 1" = 100'
6X VERTICAL EXAGGERATION

FIGURE 6-7C

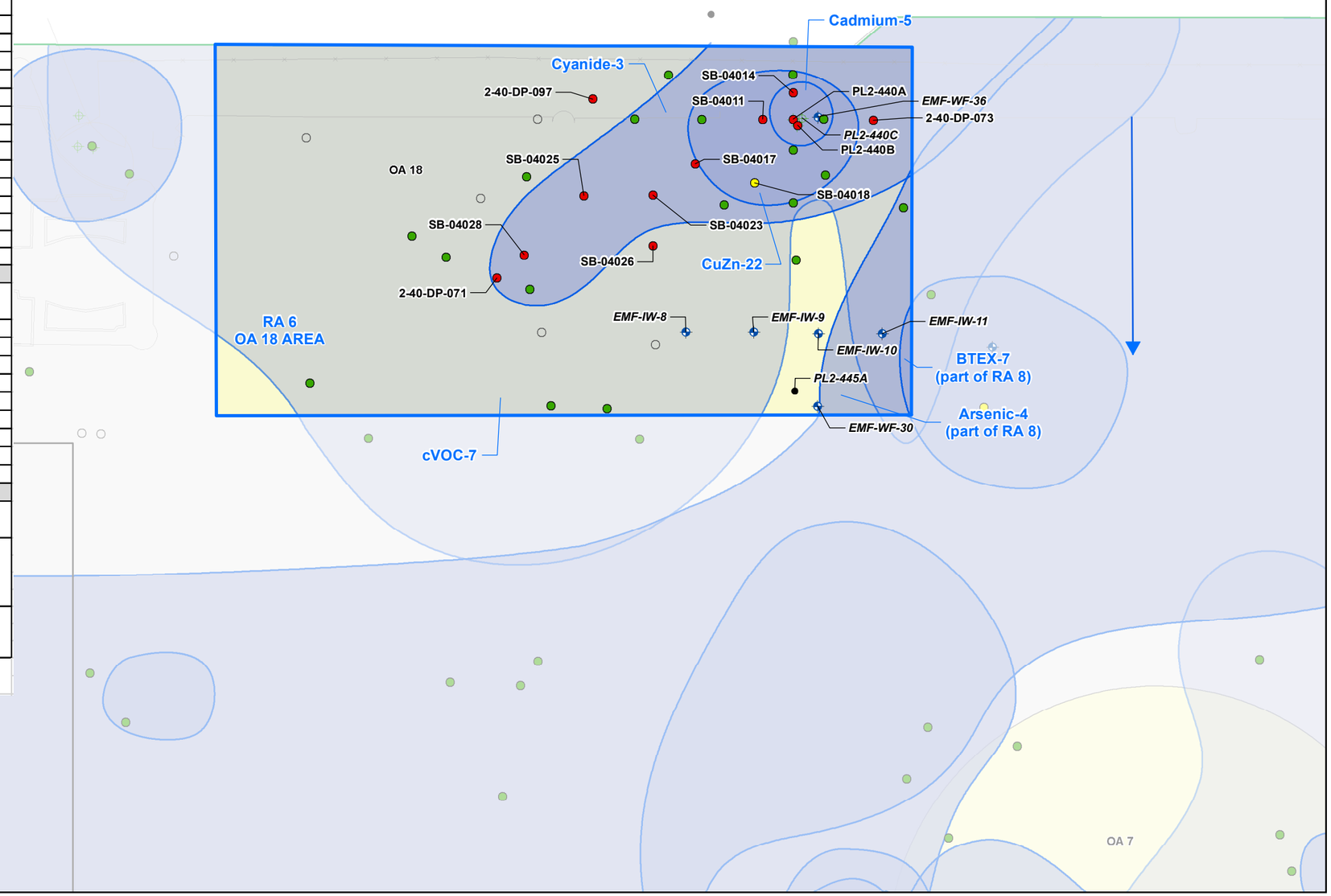
RA 5 SOUTH YARD AREA CONCEPTUAL SITE MODEL
BASED ON DATA THROUGH JANUARY 2013

PREPARED BY	ENVIRONMENTAL PARTNERS INC		
REPORT	CMS VOLUME X		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILLA WASHINGTON		
PREPARED FOR	THE BOEING COMPANY		
DATE 10/23/17	***DRAWN BY*** VPB	***REVIEWED BY*** DCK	***PROJECT NUMBER*** 17517.0.100.01

RA 6 - OA 18 Area FMCL and SL Exceedance Locations

Constituent	FMCL mg/kg	Soil Sample Location	Concentration mg/kg	Depth feet bgs
Soil Direct Contact (0-11 feet bgs)				
Cyanide	12	PL2-440B	31.3 and 1,130	5
		SB-04014	33	7
		PL2-440A	4,600	5
cPAH	2.1	SB-04025	5.925	3.5
		SB-04023	6.786	2
		2-40-DP-073	12.448	5
		SB-04011	19.7	3.5
		2-40-DP-097	21.3	5
		PL2-440A	25.82	5
		SB-04017	39.93	1.5
		2-40-DP-071	79.68	1
		SB-04028	102.83	1
		SB-04026	32.65 and 270	6.5 and 3
		PL2-440B	34.32 and 59.7	5 and 1
Naphthalene*	170	SB-04011	490	3.5
		SB-04026	520	3
DRPH	17,000	SB-04026	23,000	3
MoRPH			20,000	3
Soil - Leaching Pathway Incomplete (6-11 feet bgs)				
Constituent	**Leaching SL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
cPAH	0.057	SB-04018	0.1321	7
		SB-04025	0.2889	7.5
		SB-04028	0.3364	10
		SB-04014	1.071	7
		SB-04011	1.333	7.5
Naphthalene	16	SB-04026	39	6.5
		SB-04011	48	7.5
GRPH	30	SB-04026	73	6.5
		SB-04014	110	7
Groundwater				
Constituent	**FMCL µg/L**	**Exceedance Area**	**Concentration µg/L**	**Aquifer Level**
Copper	8.0	CuZn-22	8.3 to 43	A-Level
Zinc	56		2490	
Cyanide	1.0	Cyanide-3	7 to 248	
Cadmium	0.21	Cadmium-5	4	
VC	0.20	cVOC-7 (EMF Plume)	0.2 to 2,300	B- Level
cDCE	130		400	
TCE	0.70		1.3	

* Naphthalene is not a soil COC; however naphthalene was detected above the proposed Industrial FMCL at locations SB-04011 and SB-04026.



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. The Soil Leaching Screening Levels are applied only to soil in the 6-11 feet bgs interval.
4. Several Interim Measures and natural degradation processes are ongoing at the time of this CMS Report submittal; final remedial action designs will be proposed based on current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC

Wells
- Current EMF Well
- Current Shoreline Monitoring Well
- Current Shoreline Monitoring Well Not Proposed for Future Shoreline Monitoring
- Other Existing Well
- Proposed New Shoreline Monitoring Well
- Proposed Property Boundary Monitoring Well
- Proposed Upgradient Monitoring Well
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)
- Groundwater Flow Direction
- Cross Section A to A'
- Remediation Area
- Groundwater Exceedance Area

Risk Management Areas
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Southwest Bank Corrective Measure Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 60
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **6-8A**
BOEING PLANT 2
RA 6 - OA 18 AREA
SOIL (0-11 FEET) AND
GROUNDWATER EXCEEDANCE AREAS
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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Golder Associates

RA 6 - OA 18 Area FMCL and SL Exceedance Locations

Constituent	FMCL mg/kg	Soil Sample Location	Concentration mg/kg	Depth feet bgs
Soil Direct Contact (0-11 feet bgs)				
Cyanide	12	PL2-440B	31.3 and 1,130	5
		SB-04014	33	7
		PL2-440A	4,600	5
cPAH	2.1	SB-04025	5.925	3.5
		SB-04023	6.786	2
		2-40-DP-073	12.448	5
		SB-04011	19.7	3.5
		2-40-DP-097	21.3	5
		PL2-440A	25.82	5
		SB-04017	39.93	1.5
		2-40-DP-071	79.68	1
		SB-04028	102.83	1
		SB-04026	32.65 and 270	6.5 and 3
		PL2-440B	34.32 and 59.7	5 and 1
Naphthalene*	170	SB-04011	490	3.5
		SB-04026	520	3
DRPH	17,000	SB-04026	23,000	3
MoRPH			20,000	3
Soil - Leaching Pathway Incomplete (6-11 feet bgs)				
Constituent	**Leaching SL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
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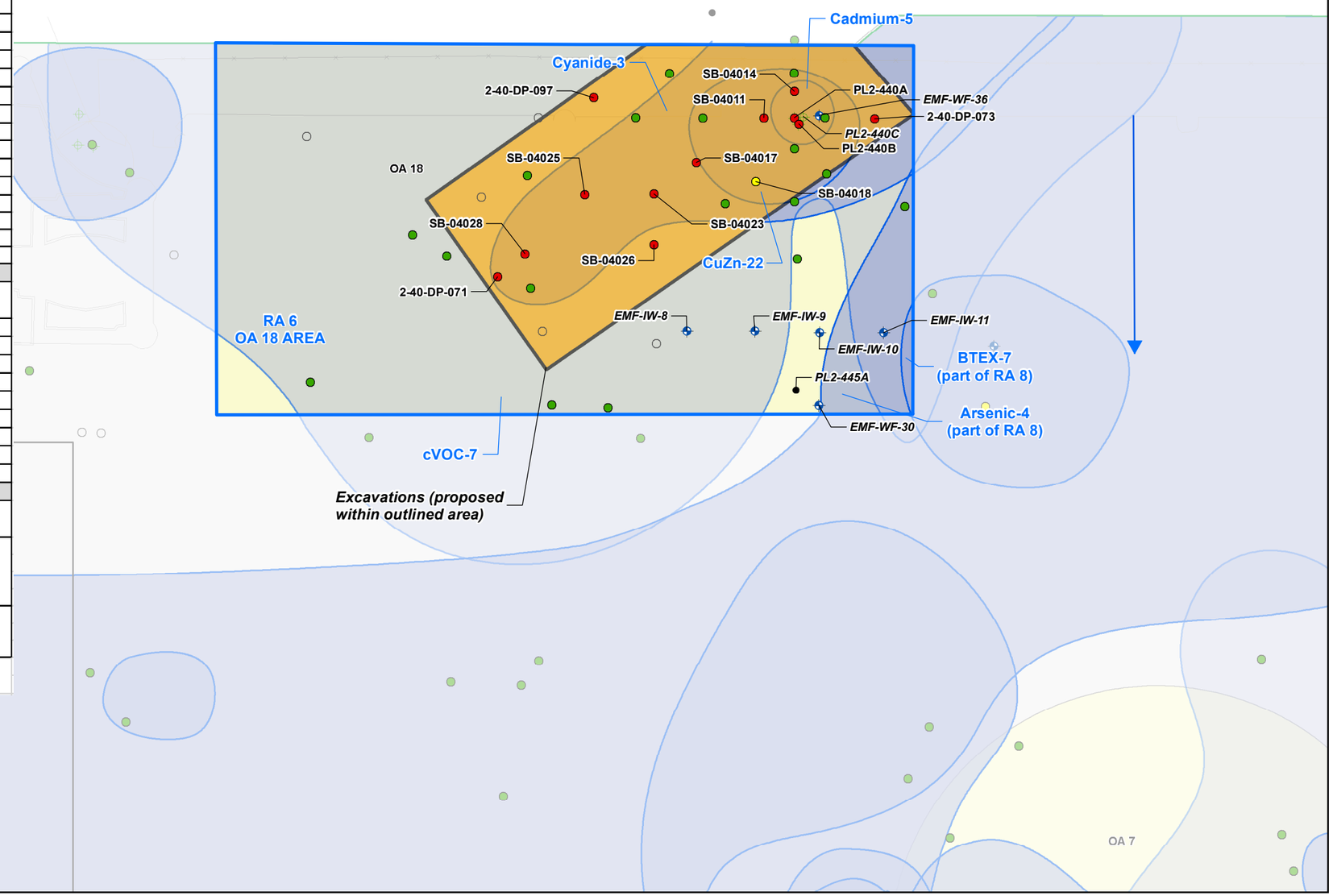
		SB-04025	0.2889	7.5
		SB-04028	0.3364	10
		SB-04014	1.071	7
		SB-04011	1.333	7.5
Naphthalene	16	SB-04026	39	6.5
		SB-04011	48	7.5
GRPH	30	SB-04026	73	6.5
		SB-04014	110	7
Groundwater				
Constituent	**FMCL µg/L**	**Exceedance Area**	**Concentration µg/L**	**Aquifer Level**
Copper	8.0	CuZn-22	8.3 to 43	A-Level
Zinc	56		2490	
Cyanide	1.0	Cyanide-3	7 to 248	
Cadmium	0.21	Cadmium-5	4	
VC	0.20	cVOC-7 (EMF Plume)	0.2 to 2,300	B- Level
cDCE	130		400	
TCE	0.70		1.3	

* Naphthalene is not a soil COC; however naphthalene was detected above the proposed Industrial FMCL at locations SB-04011 and SB-04026.

NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. The Soil Leaching Screening Levels are applied only to soil in the 6-11 feet bgs interval.
4. Several Interim Measures and natural degradation processes are ongoing at the time of this CMS Report submittal; final remedial action designs will be proposed based on current data available at the time of the CMI Work Plan (see Section 6 for details).
5. The final locations and extent of remedial actions will be based on results of a remedial action design investigation.



LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC

Wells
- Current EMF Well
- Current Shoreline Monitoring Well
- Current Shoreline Monitoring Well Not Proposed for Future Shoreline Monitoring
- Other Existing Well
- Proposed New Shoreline Monitoring Well
- Proposed Ongoing ERD Injection Well
- Proposed Property Boundary Monitoring Well
- Proposed Upgradient Monitoring Well
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)
- Groundwater Flow Direction
- Cross Section A to A'
- Remediation Area
- Groundwater Exceedance Area
- Planned Soil Excavation Area

Risk Management Areas
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Southwest Bank Corrective Measure Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 60
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **6-8B**
BOEING PLANT 2
RA 6 - OA 18 AREA
RECOMMENDED ALTERNATIVE 2
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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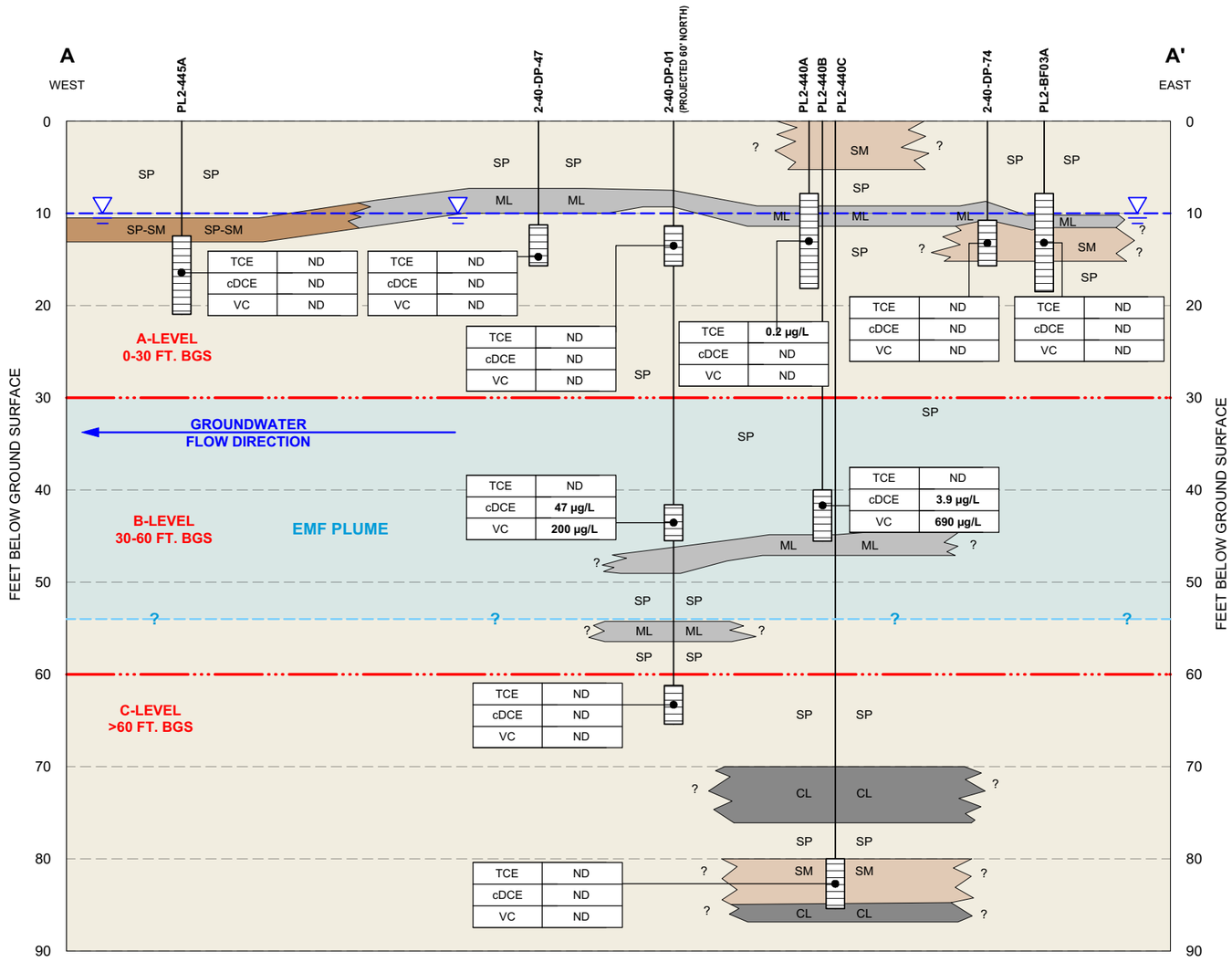
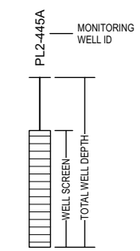
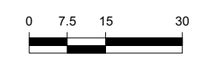
Golder Associates



NOTES:

SM	SILTY SAND
SP	POORLY-GRADED SAND
ML	SILT
CL	CLAY OF LOW PLASTICITY, LEAN CLAY
SP-SM	POORLY-GRADED SAND WITH SILT
EMF	ELECTRICAL MANUFACTURING FACILITY
TCE	TRICHLOROETHENE
cDCE	CIS-1,2-DICHLOROETHENE
VC	VINYL CHLORIDE
ND	NOT DETECTED
NS	NOT SAMPLED
µg/L	MICROGRAMS PER LITER
	GROUNDWATER LEVEL
	GROUNDWATER FLOW DIRECTION
	<1,000 µg/L FMCL EXCEEDANCE AREA





SCALE: 1" = 30'
2X VERTICAL EXAGGERATION

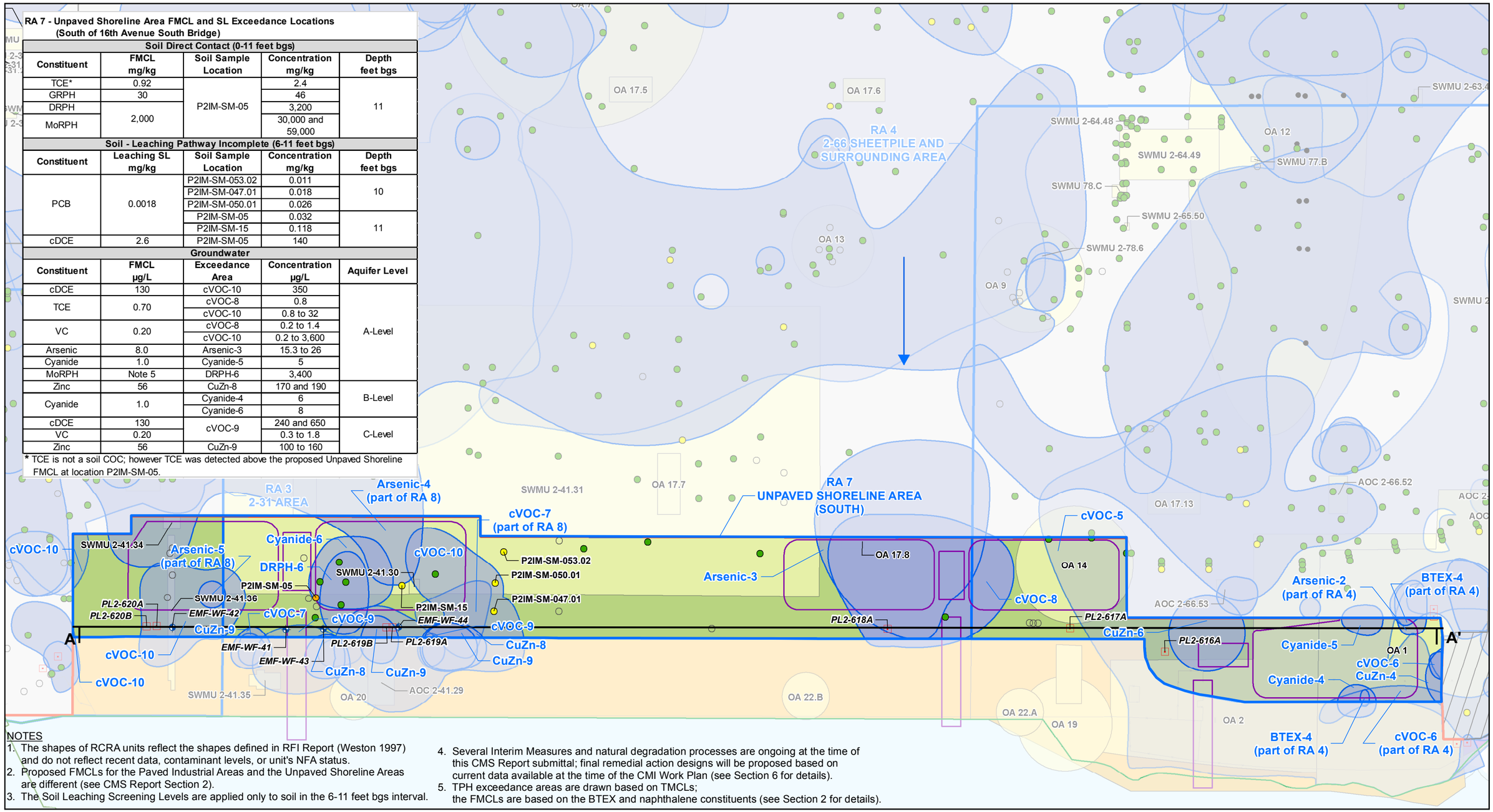
FIGURE 6-8C
RA 6-OA-18 AREA CONCEPTUAL SITE MODEL
BASED ON DATA THROUGH JANUARY 2013

PREPARED BY	ENVIRONMENTAL PARTNERS INC		
REPORT	CMS VOLUME X		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILLA WASHINGTON		
PREPARED FOR	THE BOEING COMPANY		
DATE 10/23/17	DRAWN BY VPB	REVIEWED BY DCK	PROJECT NUMBER 17517.0.100.01

RA 7 - Unpaved Shoreline Area FMCL and SL Exceedance Locations
(South of 16th Avenue South Bridge)

Constituent	FMCL mg/kg	Soil Sample Location	Concentration mg/kg	Depth feet bgs
Soil Direct Contact (0-11 feet bgs)				
TCE*	0.92	P2IM-SM-05	2.4	11
GRPH	30		46	
DRPH	2,000		3,200	
MoRPH			30,000 and 59,000	
Soil - Leaching Pathway Incomplete (6-11 feet bgs)				
Constituent	**Leaching SL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
PCB	0.0018	P2IM-SM-053.02	0.011	10
		P2IM-SM-047.01	0.018	
		P2IM-SM-050.01	0.026	
		P2IM-SM-05	0.032	11
		P2IM-SM-15	0.118	
cDCE	2.6	P2IM-SM-05	140	
Groundwater				
Constituent	**FMCL µg/L**	**Exceedance Area**	**Concentration µg/L**	**Aquifer Level**
cDCE	130	cVOC-10	350	A-Level
TCE	0.70	cVOC-8	0.8	
		cVOC-10	0.8 to 32	
VC	0.20	cVOC-8	0.2 to 1.4	
		cVOC-10	0.2 to 3,600	
Arsenic	8.0	Arsenic-3	15.3 to 26	
Cyanide	1.0	Cyanide-5	5	
MoRPH	Note 5	DRPH-6	3,400	
Zinc	56	CuZn-8	170 and 190	B-Level
Cyanide	1.0	Cyanide-4	6	
		Cyanide-6	8	
cDCE	130	cVOC-9	240 and 650	C-Level
VC	0.20		0.3 to 1.8	
Zinc	56	CuZn-9	100 to 160	

* TCE is not a soil COC; however TCE was detected above the proposed Unpaved Shoreline FMCL at location P2IM-SM-05.



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. The Soil Leaching Screening Levels are applied only to soil in the 6-11 feet bgs interval.
4. Several Interim Measures and natural degradation processes are ongoing at the time of this CMS Report submittal; final remedial action designs will be proposed based on current data available at the time of the CMI Work Plan (see Section 6 for details).
5. TPH exceedance areas are drawn based on TMCLs; the FMCLs are based on the BTEX and naphthalene constituents (see Section 2 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC

Wells
- Current EMF Well
- Current Shoreline Monitoring Well
- Current Shoreline Monitoring Well Not Proposed for Future Shoreline Monitoring
- Other Existing Well
- Proposed New Shoreline Monitoring Well
- Proposed Property Boundary Monitoring Well
- Proposed Upgradient Monitoring Well
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)
- Groundwater Flow Direction
- Cross Section A to A'
- Remediation Area
- Groundwater Exceedance Area

Risk Management Areas
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Southwest Bank Corrective Measure Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 100
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **6-9A1**

BOEING PLANT 2

RA - 7 - UNPAVED SHORELINE AREA (SOUTH)
SOIL (0-11 FEET) AND
GROUNDWATER EXCEEDANCE AREAS

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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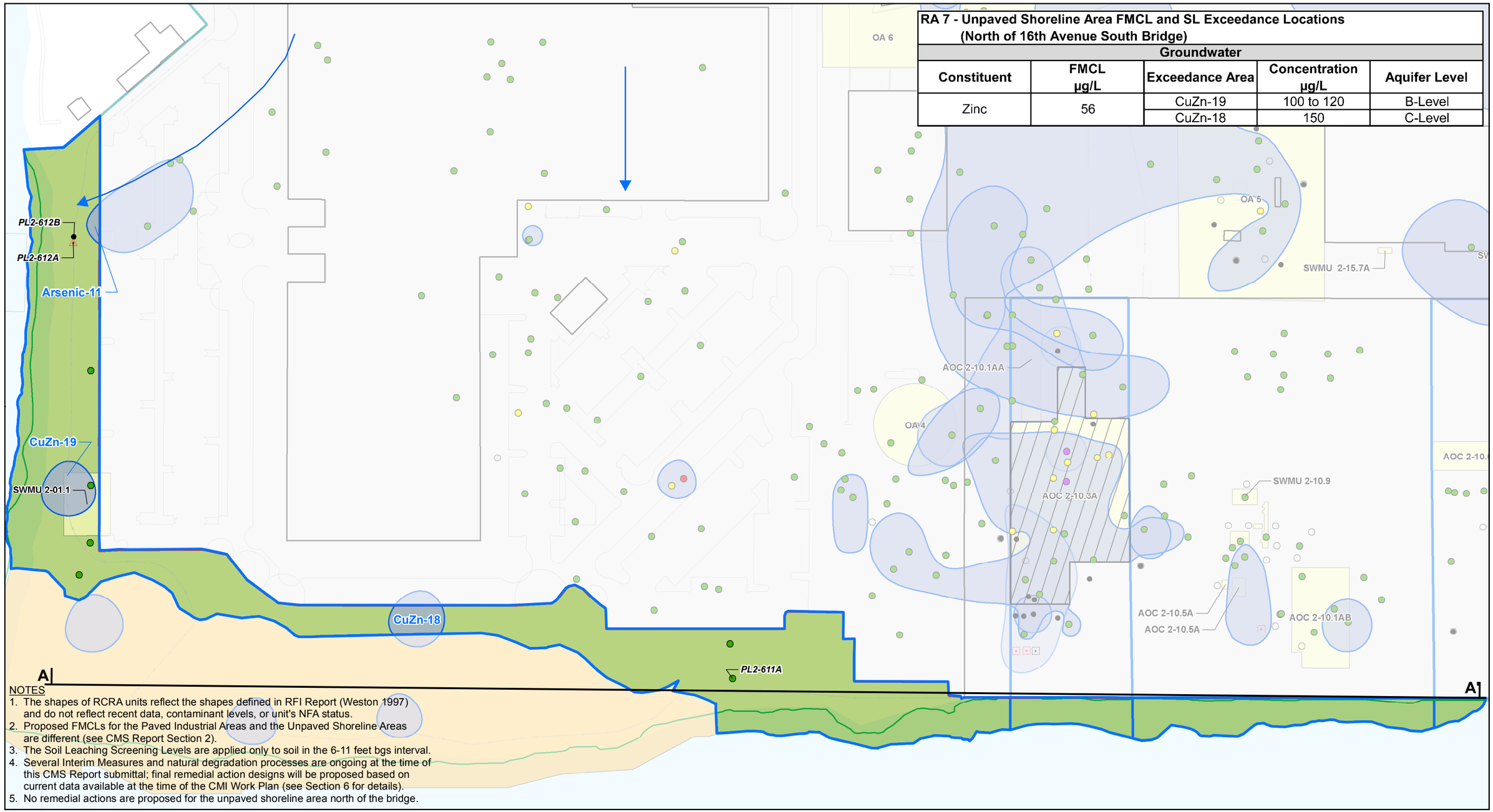
Golder Associates



RA 7 - Unpaved Shoreline Area FMCL and SL Exceedance Locations (North of 16th Avenue South Bridge)

Groundwater				
Constituent	FMCL µg/L	Exceedance Area	Concentration µg/L	Aquifer Level
Zinc	56	CuZn-19	100 to 120	B-Level
		CuZn-18	150	C-Level

NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. The Soil Leaching Screening Levels are applied only to soil in the 6-11 feet bgs interval.
4. Several Interim Measures and natural degradation processes are ongoing at the time of this CMS Report submittal; final remedial action designs will be proposed based on current data available at the time of the CMI Work Plan (see Section 6 for details).
5. No remedial actions are proposed for the unpaved shoreline area north of the bridge.

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC

Wells
- Current EMF Well
- Current Shoreline Monitoring Well
- Current Shoreline Monitoring Well Not Proposed for Future Shoreline Monitoring
- Other Existing Well
- Proposed New Shoreline Monitoring Well
- Proposed Property Boundary Monitoring Well
- Proposed Upgradient Monitoring Well

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)
- Groundwater Flow Direction
- Cross Section A to A'
- Remediation Area
- Groundwater Exceedance Area

Risk Management Areas
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Southwest Bank Corrective Measure Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 100
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

N

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **6-9A2**

BOEING PLANT 2

RA - 7 - UNPAVED SHORELINE AREA (NORTH) SOIL (0-11 FEET) AND GROUNDWATER EXCEEDANCE AREAS

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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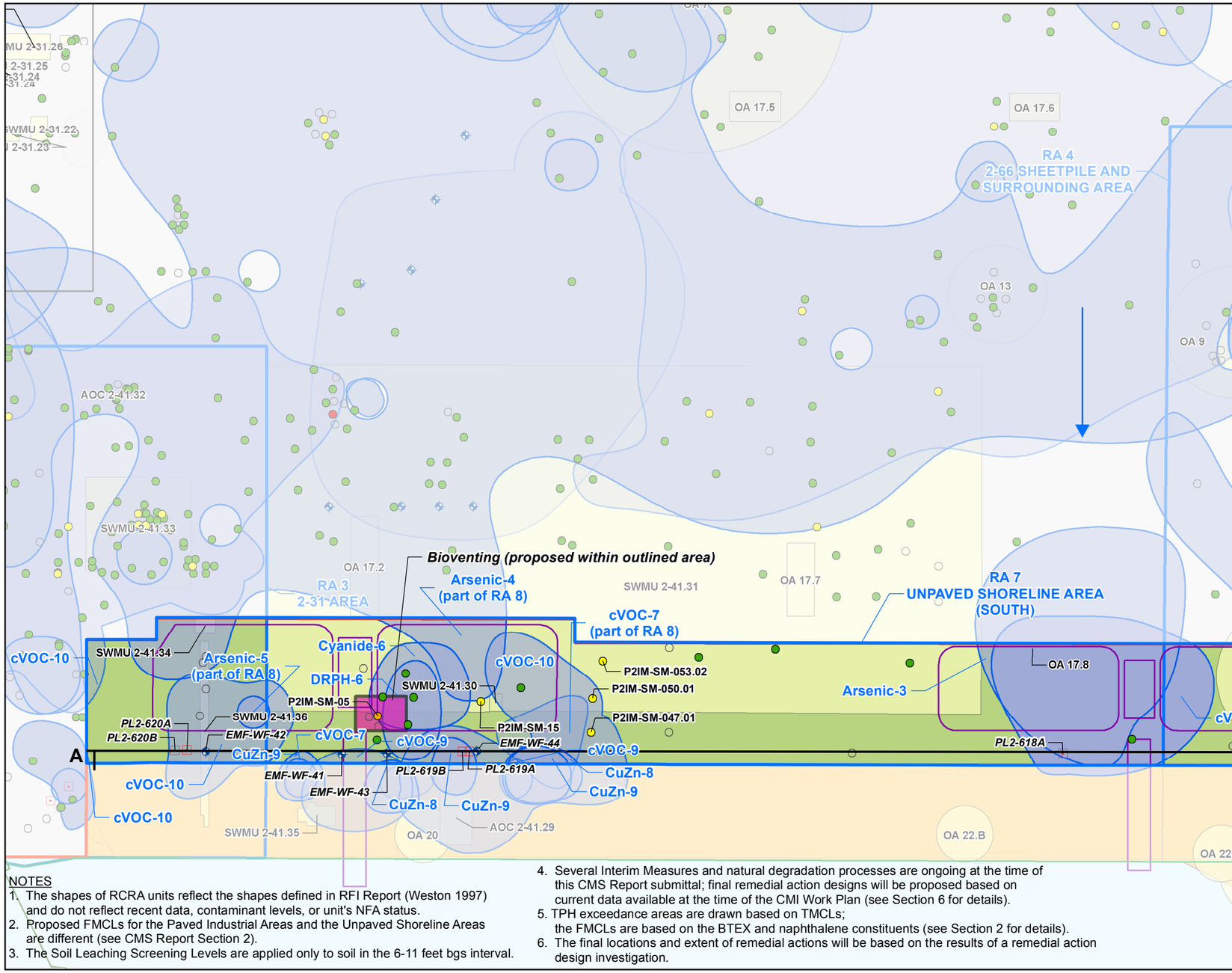
Golder Associates



RA 7 - Unpaved Shoreline Area FMCL and SL Exceedance Locations (South of 16th Avenue South Bridge)

Soil Direct Contact (0-11 feet bgs)

Constituent	FMCL mg/kg	Soil Sample Location	Concentration mg/kg	Depth feet bgs
TCE*	0.92	P2IM-SM-05	2.4	11
GRPH	30		46	
DRPH	2,000		3,200	
MoRPH			30,000 and 59,000	

Soil - Leaching Pathway Incomplete (6-11 feet bgs)

Constituent	Leaching SL mg/kg	Soil Sample Location	Concentration mg/kg	Depth feet bgs
PCB	0.0018	P2IM-SM-053.02	0.011	10
		P2IM-SM-047.01	0.018	
		P2IM-SM-050.01	0.026	
		P2IM-SM-05	0.032	11
		P2IM-SM-15	0.118	
cDCE	2.6	P2IM-SM-05	140	

Groundwater

Constituent	FMCL µg/L	Exceedance Area	Concentration µg/L	Aquifer Level
cDCE	130	cVOC-10	350	A-Level
TCE	0.70	cVOC-8	0.8	
		cVOC-10	0.8 to 32	
VC	0.20	cVOC-8	0.2 to 1.4	
		cVOC-10	0.2 to 3,600	
Arsenic	8.0	Arsenic-3	15.3 to 26	
Cyanide	1.0	Cyanide-5	5	
MoRPH	Note 5	DRPH-6	3,400	
Zinc	56	CuZn-8	170 and 190	B-Level
Cyanide	1.0	Cyanide-4	6	
		Cyanide-6	8	
cDCE	130	cVOC-9	240 and 650	C-Level
VC	0.20		0.3 to 1.8	
Zinc	56	CuZn-9	100 to 160	

* TCE is not a soil COC; however TCE was detected above the proposed Unpaved Shoreline FMCL at location P2IM-SM-05.

NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. The Soil Leaching Screening Levels are applied only to soil in the 6-11 feet bgs interval.
4. Several Interim Measures and natural degradation processes are ongoing at the time of this CMS Report submittal; final remedial action designs will be proposed based on current data available at the time of the CMI Work Plan (see Section 6 for details).
5. TPH exceedance areas are drawn based on TMCLs; the FMCLs are based on the BTEX and naphthalene constituents (see Section 2 for details).
6. The final locations and extent of remedial actions will be based on the results of a remedial action design investigation.

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC

Wells
- Current EMF Well
- Current Shoreline Monitoring Well
- Current Shoreline Monitoring Well Not Proposed for Future Shoreline Monitoring
- Other Existing Well
- Proposed New Shoreline Monitoring Well
- Proposed Ongoing ERD Injection Well
- Proposed Property Boundary Monitoring Well
- Proposed Upgradient Monitoring Well

- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)
- Groundwater Flow Direction
- Cross Section A to A'
- Remediation Area
- Groundwater Exceedance Area
- Proposed Bioventing Area

Risk Management Areas
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Southwest Bank Corrective Measure Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 100
Scale in Feet

N

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **6-9B**

BOEING PLANT 2

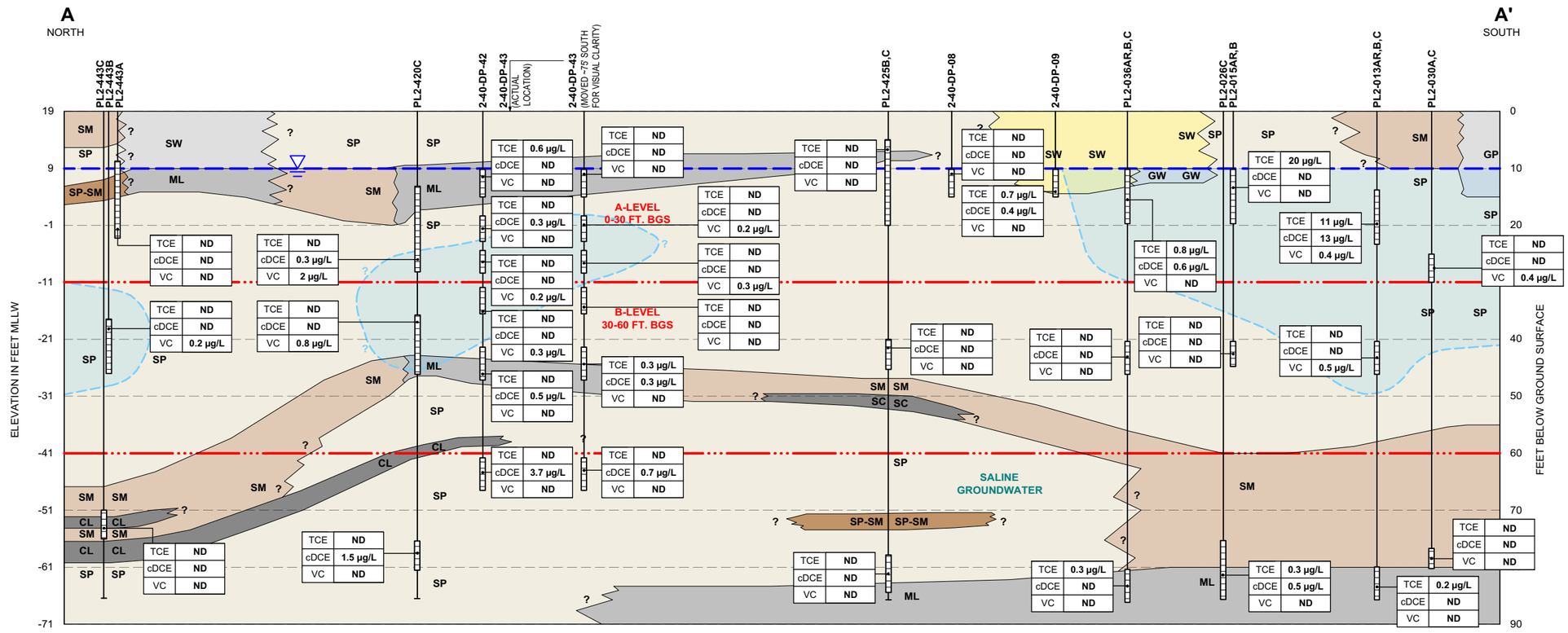
RA - 7 - UNPAVED SHORELINE AREA (SOUTH)

RECOMMENDED ALTERNATIVE 2

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

Path: G:\Boeing\Plant 2\99_PROJECTS\0131646017_CMS_CONSTRUCTION_SUPPORT\100_CMS_SOB_CMI\02_PRODUCTION\MXD\FIGURES\CMS_Report\Rev0\0131646017_100_069_F_6_9B_Rev0_SouthShorelineAreaSoil_RA7.mxd Date: 11/2/2017 User: HJackson

Golder Associates



0 32.5 65 130

SCALE: 1" = 130'
3X VERTICAL EXAGGERATION

NOTES:

GW	WELL-GRADED GRAVEL
GP	POORLY-GRADED GRAVEL
SW	WELL-GRADED SAND
SM	SILTY SAND
SP	POORLY-GRADED SAND
SC	CLAYEY SAND
ML	SILT
CL	CLAY OF LOW PLASTICITY, LEAN CLAY
SP-SM	POORLY-GRADED SAND WITH SILT

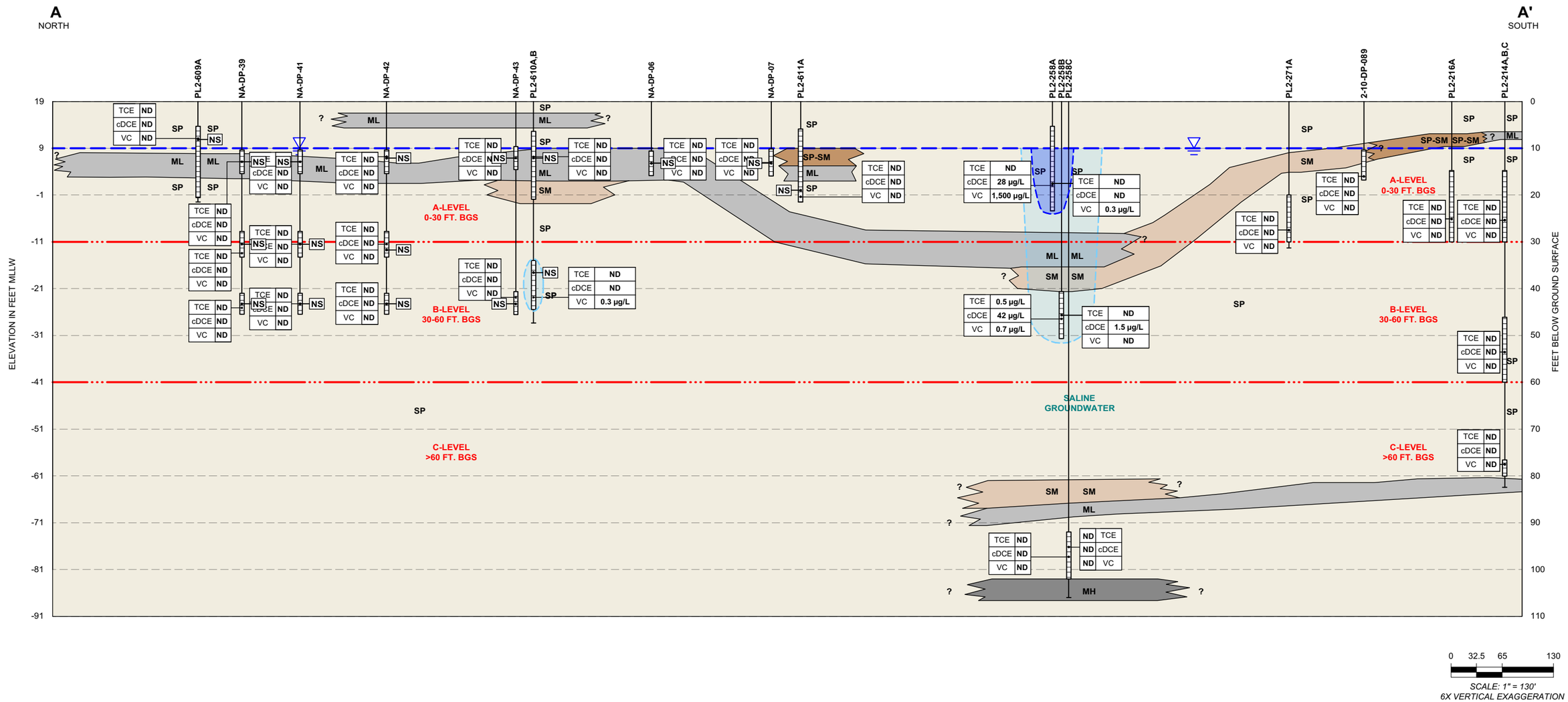
	GROUNDWATER LEVEL
	<1,000 µg/L FMCL EXCEEDANCE AREA
µg/L	MICROGRAMS PER LITER
TCE	TRICHLOROETHENE
cDCE	CIS-1,2-DICHLOROETHENE
VC	VINYL CHLORIDE
ND	NOT DETECTED
NS	NOT SAMPLED

PL2-609A — MONITORING WELL ID
WELL SCREEN
TOTAL WELL DEPTH

FIGURE 6-9C1

RA 7 UNPAVED SHORELINE AREA (SOUTH) CONCEPTUAL SITE MODEL BASED ON DATA THROUGH JANUARY 2013

PREPARED BY	ENVIRONMENTAL PARTNERS INC		
REPORT	CMS VOLUME X		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILLA WASHINGTON		
PREPARED FOR	THE BOEING COMPANY		
DATE 10/23/17	***DRAWN BY*** VPB	***REVIEWED BY*** DCK	***PROJECT NUMBER*** 17517.0.100.01



NOTES:

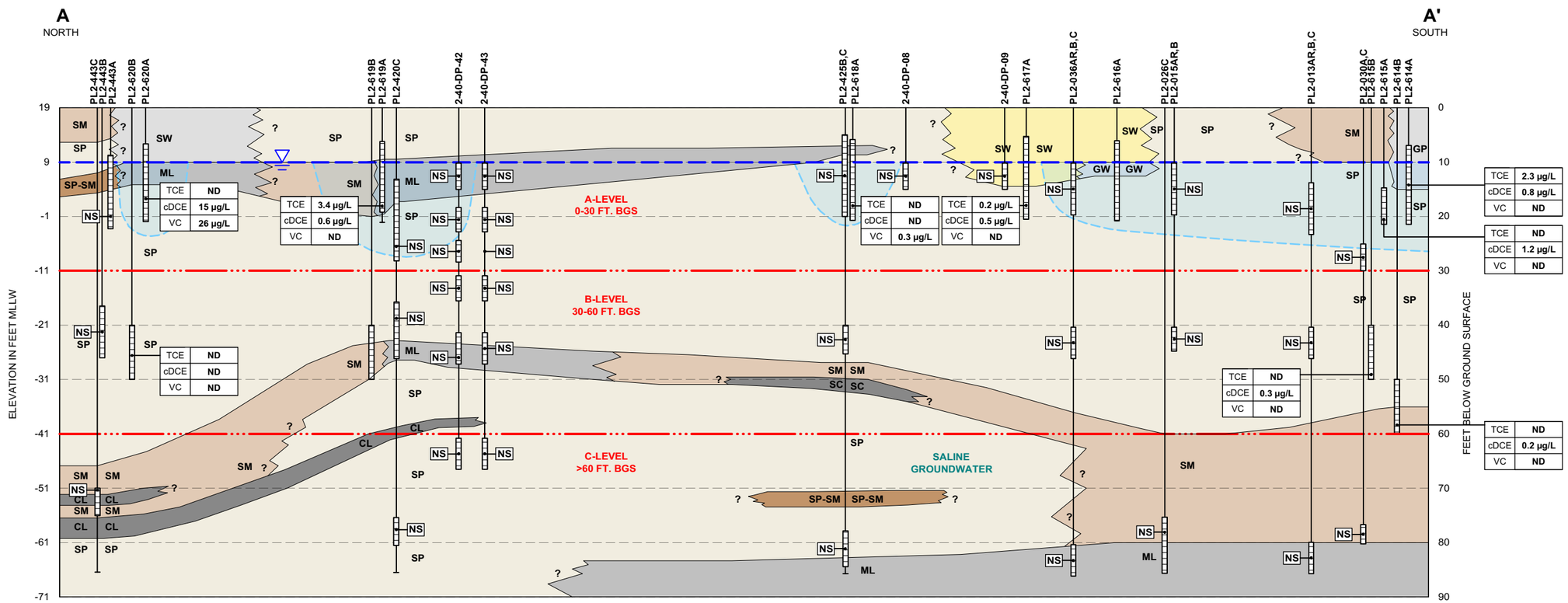
SM	SILTY SAND
SP	POORLY-GRADED SAND
ML	SILT
MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
SP-SM	POORLY-GRADED SAND WITH SILT
TCE	TRICHLOROETHENE
cDCE	CIS-1,2-DICHLOROETHENE
VC	VINYL CHLORIDE
	GROUNDWATER LEVEL
	>1,000 µg/L FMCL EXCEEDANCE AREA
	<1,000 µg/L FMCL EXCEEDANCE AREA
ND	NOT DETECTED
NS	NOT SAMPLED
µg/L	MICROGRAMS PER LITER

PL2-609A — MONITORING WELL ID
WELL SCREEN
TOTAL WELL DEPTH

FIGURE 6-9C2

RA 7 UNPAVED SHORELINE AREA (NORTH) CONCEPTUAL SITE MODEL BASED ON DATA THROUGH JANUARY 2013

PREPARED BY	ENVIRONMENTAL PARTNERS INC		
REPORT	CMS VOLUME X		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILLA WASHINGTON		
PREPARED FOR	THE BOEING COMPANY		
DATE 10/23/17	**DRAWN BY** VPB	**REVIEWED BY** DCK	**PROJECT NUMBER** 17517.0.100.01



0 32.5 65 130

SCALE: 1" = 130'
3X VERTICAL EXAGGERATION

NOTES:

GW	WELL-GRADED GRAVEL
GP	POORLY-GRADED GRAVEL
SW	WELL-GRADED SAND
SM	SILTY SAND
SP	POORLY-GRADED SAND
SC	CLAYEY SAND
ML	SILT
CL	CLAY OF LOW PLASTICITY, LEAN CLAY
SP-SM	POORLY-GRADED SAND WITH SILT

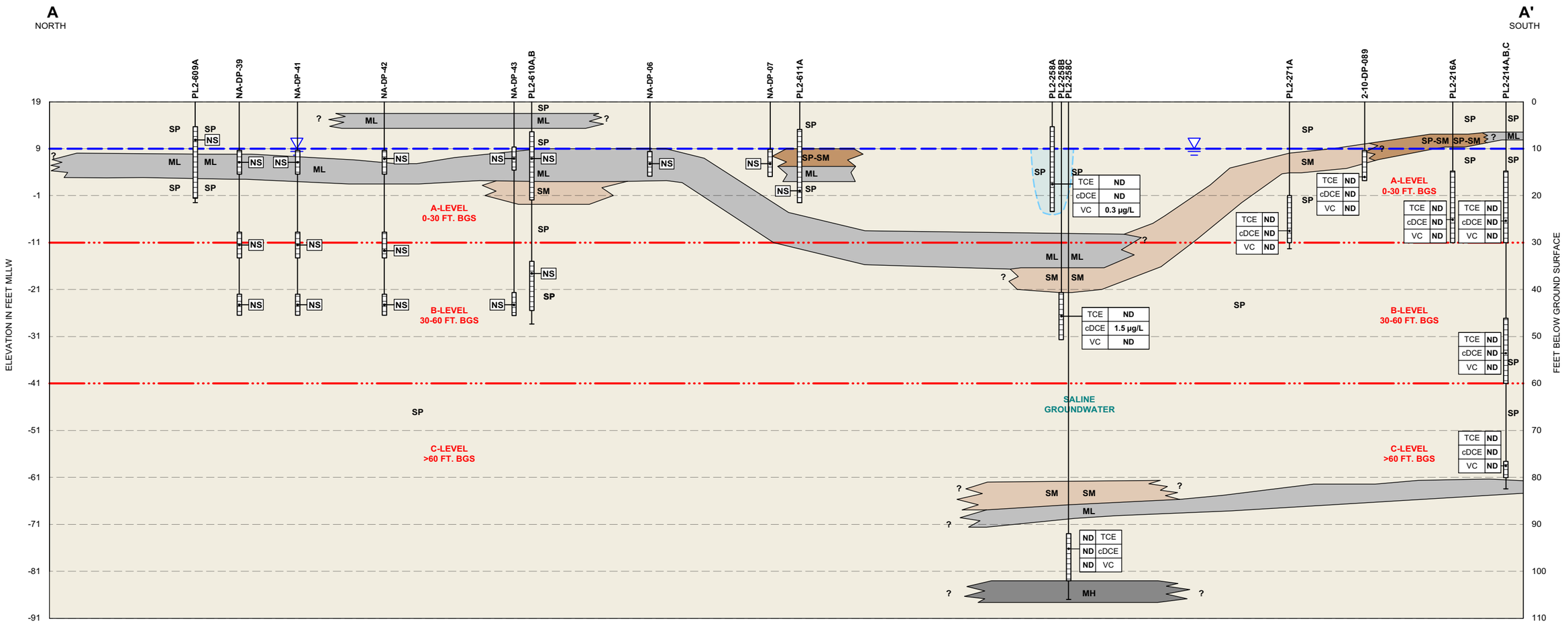
	GROUNDWATER LEVEL
	<1,000 µg/L FMCL EXCEEDANCE AREA
µg/L	MICROGRAMS PER LITER
TCE	TRICHLOROETHENE
cDCE	CIS-1,2-DICHLOROETHENE
VC	VINYL CHLORIDE
ND	NOT DETECTED
NS	NOT SAMPLED

PL2-609A — MONITORING WELL ID
WELL SCREEN
TOTAL WELL DEPTH

FIGURE 6-9D1

RA 7 UNPAVED SHORELINE AREA (SOUTH) CONCEPTUAL SITE MODEL ADJUSTED WITH DATA THROUGH DECEMBER 2016 WHERE APPLICABLE

PREPARED BY	ENVIRONMENTAL PARTNERS INC		
REPORT	CMS VOLUME X		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILLA WASHINGTON		
PREPARED FOR	THE BOEING COMPANY		
DATE 10/23/17	***DRAWN BY*** VPB	***REVIEWED BY*** DCK	***PROJECT NUMBER*** 17517.0.100.01



0 32.5 65 130

SCALE: 1" = 130'
6X VERTICAL EXAGGERATION

NOTES:

SM	SILTY SAND
SP	POORLY-GRADED SAND
ML	SILT
MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
SP-SM	POORLY-GRADED SAND WITH SILT
TCE	TRICHLOROETHENE
cDCE	CIS-1,2-DICHLOROETHENE
VC	VINYL CHLORIDE

GROUNDWATER LEVEL

<1,000 µg/L FMCL EXCEEDANCE AREA

ND	NOT DETECTED
NS	NOT SAMPLED
µg/L	MICROGRAMS PER LITER

PL2-609A — MONITORING WELL ID

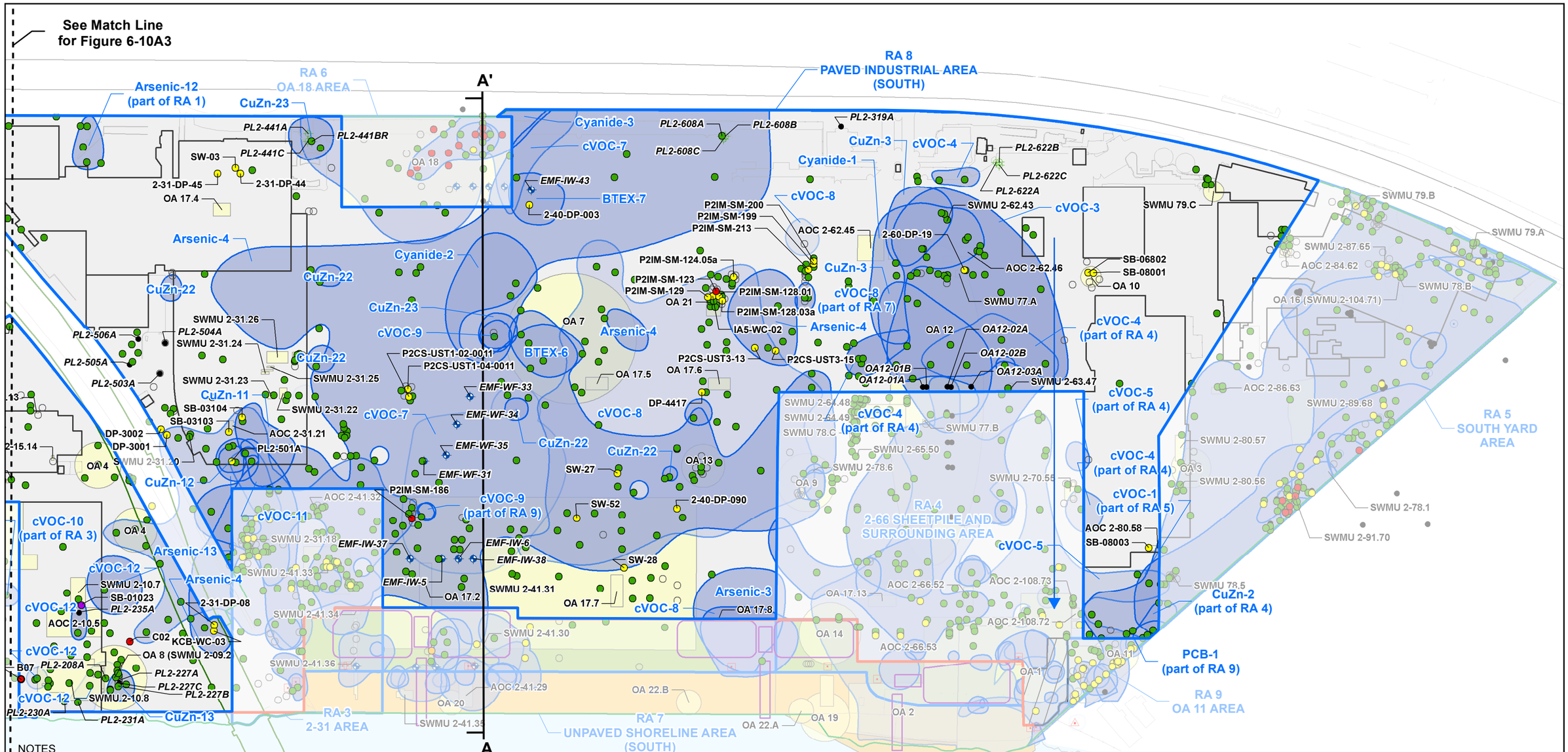
WELL SCREEN

TOTAL WELL DEPTH

FIGURE 6-9D2

RA 7 UNPAVED SHORELINE AREA (NORTH) CONCEPTUAL SITE MODEL ADJUSTED WITH DATA THROUGH DECEMBER 2016 WHERE APPLICABLE

PREPARED BY	ENVIRONMENTAL PARTNERS INC		
REPORT	CMS VOLUME X		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILLA WASHINGTON		
PREPARED FOR	THE BOEING COMPANY		
DATE 10/23/17	***DRAWN BY*** VPB	***REVIEWED BY*** DCK	***PROJECT NUMBER*** 17517.0.100.01



NOTES

1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. RA 8 comprises the Paved Industrial Area, except for those areas included in other RAs.
4. RA 7 comprises the Unpaved Shoreline Area.
5. The Soil Leaching Screening Levels are applied only to soil in the 6-11 feet bgs interval.
6. Several Interim Measures and natural degradation processes are ongoing at the time of this CMS Report submittal; final remedial action designs will be proposed based on current data available at the time of the CMI Work Plan (see Section 6 for details).

NOTE
South Industrial Area FMCL exceedance locations (South of 16th Avevue S. Bridge) are provided on the following page (2 of 2).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC

Wells
- Current EMF Well
- Current Shoreline Monitoring Well
- Current Shoreline Monitoring Well Not Proposed for Future Shoreline Monitoring
- Other Existing Well
- Proposed New Shoreline Monitoring Well
- Proposed Property Boundary Monitoring Well
- Proposed Upgradient Monitoring Well
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)
- Groundwater Flow Direction
- Cross Section A to A'
- Remediation Area
- Groundwater Exceedance Area

Risk Management Areas
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Southwest Bank Corrective Measure Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 200
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

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This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE 1 OF 2 **6-10A1**

BOEING PLANT 2

RA 8 - PAVED INDUSTRIAL AREA (SOUTH)
SOIL (0-11 FEET) AND
GROUNDWATER EXCEEDANCE AREAS

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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Golder Associates

RA 8 - Paved Industrial Area FMCL and SL Exceedance Locations (South of 16th Avenue S Bridge)

Soil Direct Contact (0-11 feet bgs)				
Constituent	**FMCL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
MoRPH	17,000	P2IM-SM-123	61,000	11
		P2IM-SM-186	24,000 and	6
Soil - Leaching Pathway (6-11 feet bgs)				
Constituent	**Leaching SL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
TCE	0.051	PL2-501A	0.1	8
		SB-03103	0.32	10
VC	0.022	SB-03104	0.061	9
		SB-03103	0.065	8
Ethylbenzene	0.23	2-40-DP-003	0.47	10
Soil - Leaching Pathway Incomplete (6-11 feet bgs)				
Constituent	**Leaching SL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
Arsenic	20	2-31-DP-44	64	10
Copper	80	2-31-DP-44	140	
Benzene	0.093	2-40-DP-090	0.11	
cPAH	0.057	SW-28	0.06393	9
		P2CS-UST1-02-0011	0.07987	11
		SW-27	0.09254	
		P2CS-UST1-04-0011	0.1193	
		SW-52	0.4984	
DRPH	2,000	DP-3001	2,700	7.5
		DP-3002	6,100	10
		SB-08001	6,800	
		SB-06802	14,000	
MoRPH		P2CS-UST1-04-0011	4,100	11
		P2IM-SM-213	9,700	
GRPH	30	P2CS-UST3-13	1,900	
		P2CS-UST3-15	2,000	10
		P2IM-SM-213	5,700	11
PCB	0.0018	P2IM-SM-213	0.013	
		P2IM-SM-124.05a	0.026	
		P2IM-SM-129	0.027	7.5
		P2IM-SM-128.03a	0.029	11
		P2IM-SM-128.01	0.035	
		2-31-DP-44	0.048	10
		SB-08003	0.052	8
		P2IM-SM-199	0.087	10
		DP-4417	0.131	
		P2IM-SM-200	0.205	
		SW-03	0.28	10.5
		2-60-DP-19	0.4	11
		2-31-DP-45	1.43	10
		IA5-WC-02	1.654	7
		P2IM-SM-123	6.8	11

RA 8 - Paved Industrial Area FMCL and SL Exceedance Locations (South of 16th Avenue S Bridge)

Groundwater				
Constituent	**FMCL µg/L**	**Exceedance Area**	**Concentration µg/L**	**Aquifer Level**
TCE	0.70	cVOC-8	0.8	A-Level
		cVOC-3	0.5	
VC	0.20		2.5 to 29	
		cVOC-8	0.2 to 1.4	
Benzene	1.6	BTEX-7	5.9	
		BTEX-6	9.2 and 9.3	
Ethylbenzene	1.7	BTEX-7	36	
Arsenic	8.0	Arsenic-4	8.3 to 41.5	
		Arsenic-3	15.3 to 26	
Copper	8.0	CuZn-22	8.3 to 43	
		CuZn-3	8.5 to 21	
		CuZn-11	13 to 20.6	
Zinc	56	CuZn-22	2490	
Cyanide		Cyanide-2	16 and 17	
		Cyanide-1	6 to 64	
VC	0.20	cVOC-7 (EMF Plume)	0.2 to 2,300	B-Level
cDCE	130		400	
TCE	0.70		1.3	
Arsenic	8.0	Arsenic-13	135	C-Level
Copper	8.0	CuZn-12	11	
Zinc	56	CuZn-13	70	
		CuZn-23	130 and 650	

Source:
Golder Associates Inc.

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FIGURE 2 OF 2 **6-10A2**

BOEING PLANT 2

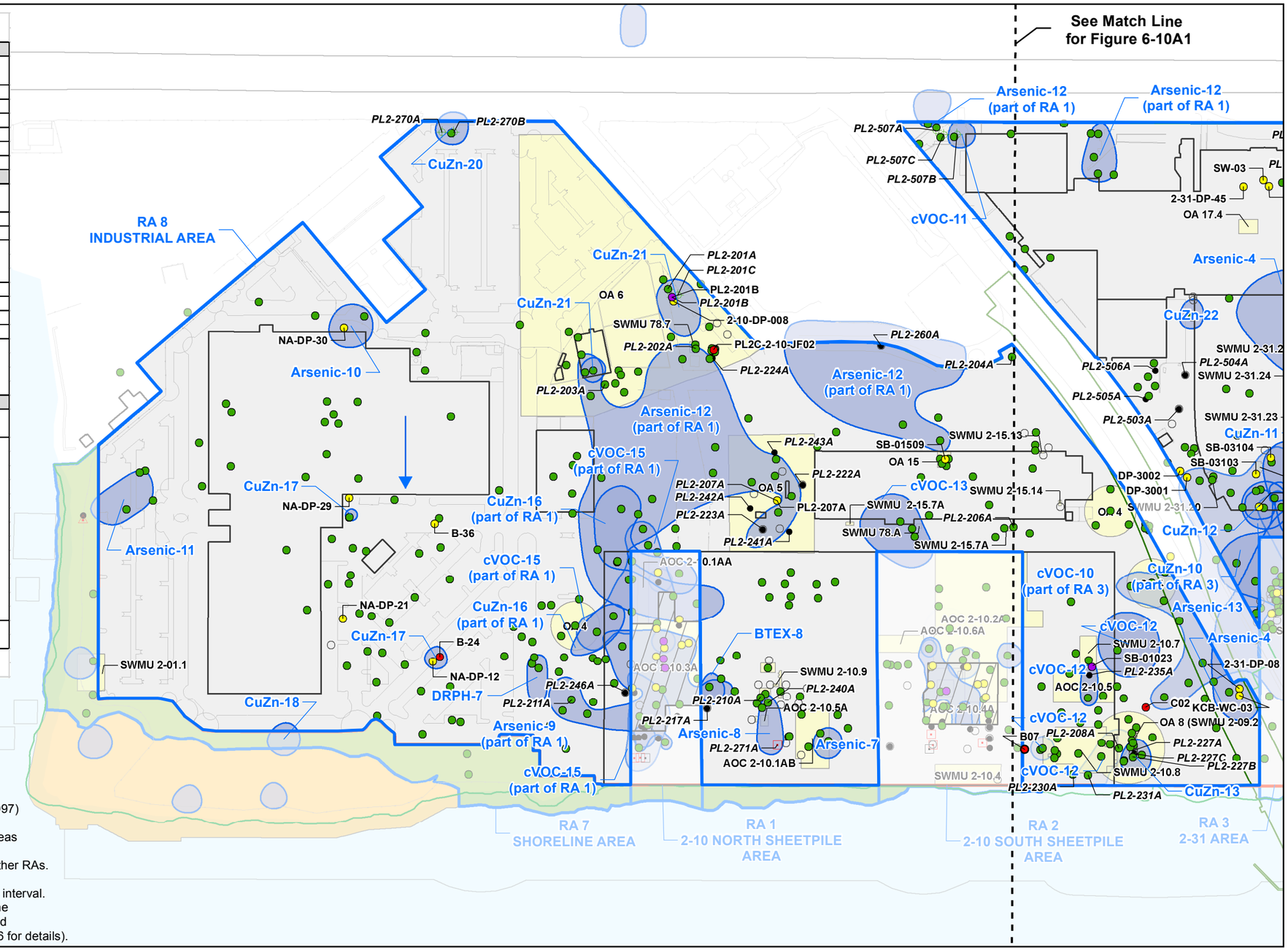
RA 8 - PAVED INDUSTRIAL AREA (SOUTH) SOIL (0-11 FEET) AND GROUNDWATER EXCEEDANCE AREAS

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

RA 8 - Paved Industrial Area FMCL and SL Exceedance Locations (North of 16th Avenue South Bridge)

Constituent	FMCL mg/kg	Soil Sample Location	Concentration mg/kg	Depth feet bgs
Soil Direct Contact (0-11 feet bgs)				
Arsenic*	88	PL2-201B	288	5
Chromium (VI)*	56	SB-01023	160	6
cPAH	2.1	B-24	2.7533	2.5 to 11.5
Cyanide	12	C02	17.1 and 19	2
		B07	21.2	5
MoRPH	17,000	PL2-2-10-JF02	40,000	3.5
Soil - Leaching Pathway Incomplete (6-11 feet bgs)				
Constituent	**Leaching SL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
Benzene	0.093	PL2-207A	0.16	10
Cadmium	3.3	KCB-WC-03	13.3	11
Copper	80	2-31-DP-08	104	10
		2-10-DP-008	100	
		NA-DP-12	118	
		B-36	310	8.5
Naphthalene	16	B-24	28	11
PCB	0.0018	NA-DP-30	0.043	10
		SB-01509	0.078	7
		NA-DP-21	0.134	10
		NA-DP-29	0.167	
		2-31-DP-08	0.190	
		2-10-DP-073	2.8	
Groundwater				
Constituent	**FMCL µg/L**	**Exceedance Area**	**Concentration µg/L**	**Aquifer Level**
TCE	0.70	cVOC-13	2.2 to 9.0	A-Level
		cVOC-12	3.1	
VC	0.20		0.2 to 1.0	
		cVOC-13	0.4 to 9.2	
Benzene	1.6	BTEX-8	31	
Arsenic	8.0	Arsenic-12	9.0 to 49.8	
		Arsenic-7	10.3	
		Arsenic-8	14.5 and 17.6	
		Arsenic-10	15.4	
		Arsenic-11	1,100	
Copper	8.0	CuZn-17	9.1 and 15.1	
		CuZn-21	10.1 to 60	
Naphthalene	26	DRPH-7	70	
Copper	8.0	CuZn-20	31.2	B-Level
Zinc	56		90	

* Arsenic and chromium are not soil COCs; however arsenic and chromium were detected above the proposed Industrial FMCL at locations PL2-201B and SB-01023, respectively.



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. RA 8 comprises the Paved Industrial Area, except for those areas included in other RAs.
4. RA 7 comprises the Unpaved Shoreline Area.
5. The Soil Leaching Screening Levels are applied only to soil in the 6-11 feet bgs interval.
6. Several Interim Measures and natural degradation processes are ongoing at the time of this CMS Report submittal; final remedial action designs will be proposed based on current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC

Wells
- Current EMF Well
- Current Shoreline Monitoring Well
- Current Shoreline Monitoring Well Not Proposed for Future Shoreline Monitoring
- Other Existing Well
- Proposed New Shoreline Monitoring Well
- Proposed Property Boundary Monitoring Well
- Proposed Upgradient Monitoring Well
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)
- Groundwater Flow Direction
- Cross Section A to A'
- Remediation Area
- Groundwater Exceedance Area

Risk Management Areas
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Southwest Bank Corrective Measure Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 200
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

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This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **6-10A3**

BOEING PLANT 2

RA 8 - PAVED INDUSTRIAL AREA (NORTH) SOIL (0-11 FEET) AND GROUNDWATER EXCEEDANCE AREAS

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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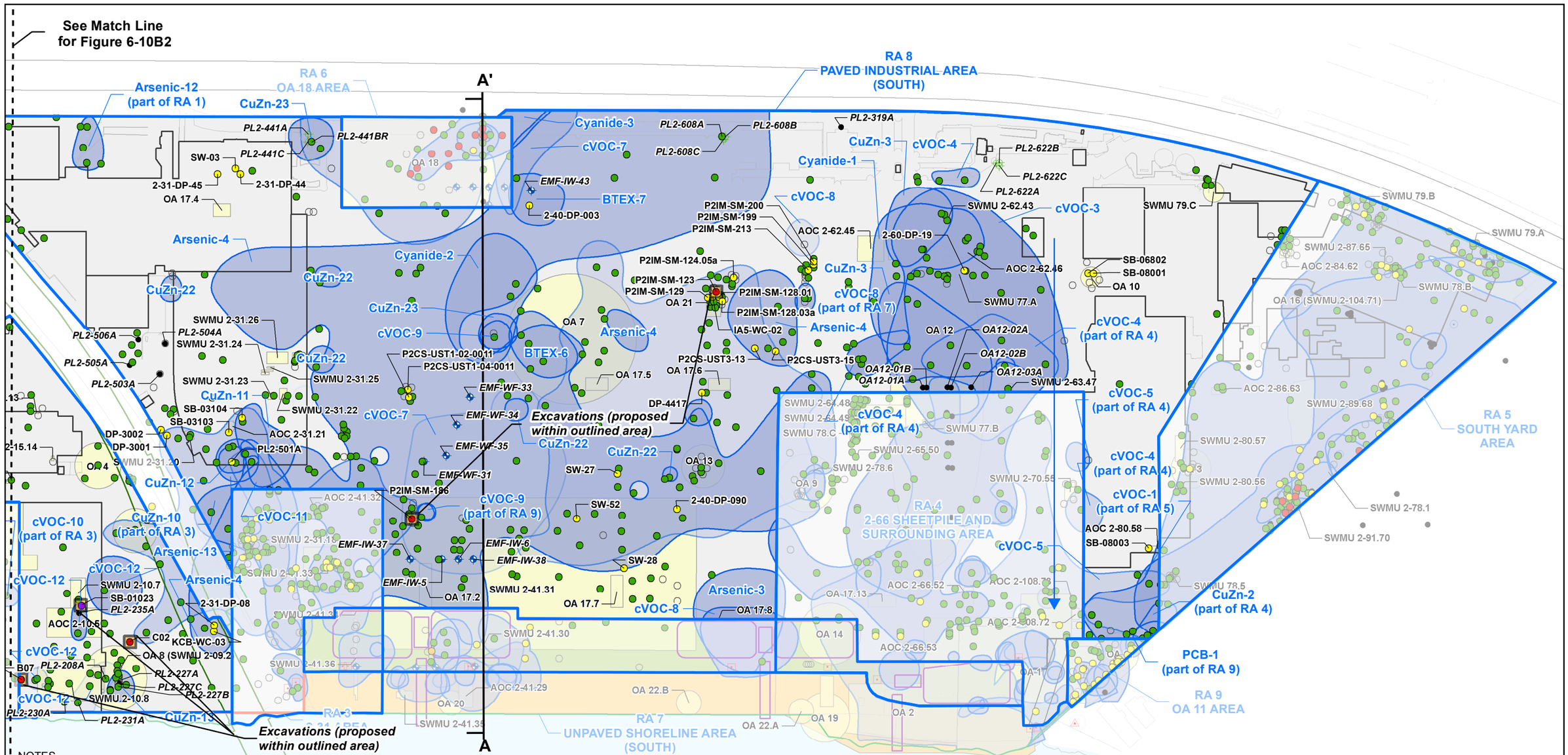
Golder Associates



NOTES

1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. RA 8 comprises the Paved Industrial Area, except for those areas included in other RAs.
4. RA 7 comprises the Unpaved Shoreline Area.
5. The Soil Leaching Screening Levels are applied only to soil in the 6-11 feet bgs interval.
6. Several Interim Measures and natural degradation processes are ongoing at the time of this CMS Report submittal; final remedial action designs will be proposed based on current data available at the time of the CMI Work Plan (see Section 6 for details).

NOTE
South Industrial Area FMCL exceedance locations (South of 16th Avevue S. Bridge) are provided on Figure 6-10A2.

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC

Wells
- Current EMF Well
- Current Shoreline Monitoring Well
- Current Shoreline Monitoring Well Not Proposed for Future Shoreline Monitoring
- Other Existing Well
- Proposed New Shoreline Monitoring Well
- Proposed Ongoing ERD Injection Well
- Proposed Property Boundary Monitoring Well
- Proposed Upgradient Monitoring Well
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)
- Groundwater Flow Direction
- Cross Section A to A'
- Remediation Area
- Groundwater Exceedance Area
- Planned Soil Excavation Area

Risk Management Areas
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Southwest Bank Corrective Measure Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 200
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **6-10B1**
BOEING PLANT 2
RA 8 - PAVED INDUSTRIAL AREA (SOUTH)
RECOMMENDED ALTERNATIVE 2
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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Golder Associates

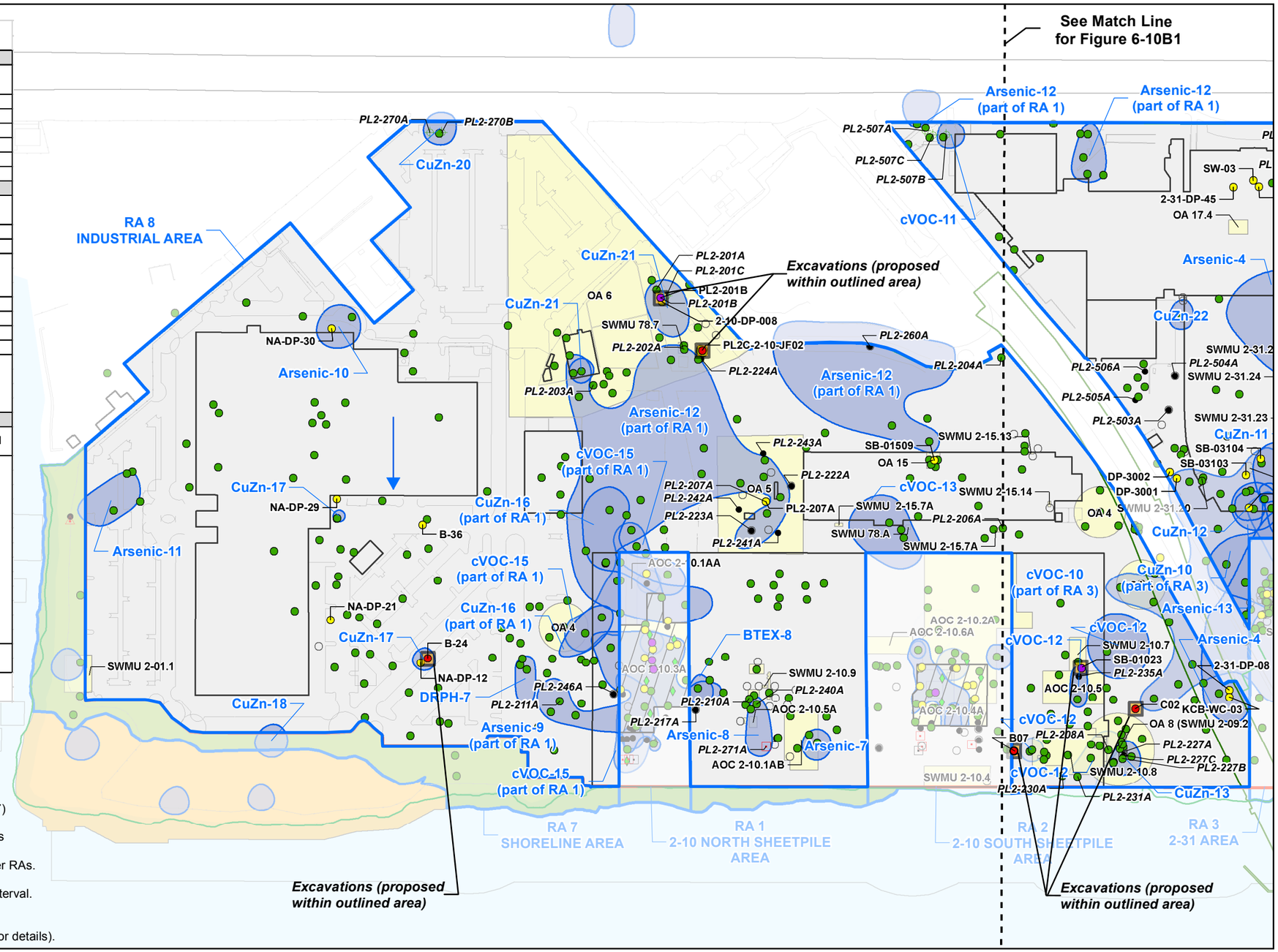
RA 8 - Paved Industrial Area FMCL and SL Exceedance Locations
(North of 16th Avenue South Bridge)

Soil Direct Contact (0-11 feet bgs)				
Constituent	**FMCL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
Arsenic*	88	PL2-201B	288	5
Chromium*	56	SB-01023	160	6
cPAH	2.1	B-24	2.7533	2.5 to 11.5
Cyanide	12	C02	17.1 and 19	2
		B07	21.2	5
MoRPH	17,000	PL2-2-10-JF02	40,000	3.5

Soil - Leaching Pathway Incomplete (6-11 feet bgs)				
Constituent	**Leaching SL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
Benzene	0.093	PL2-207A	0.16	10
Cadmium	3.3	KCB-WC-03	13.3	11
Copper	80	2-31-DP-08	104	10
		2-10-DP-008	100	
		NA-DP-12	118	
		B-36	310	8.5
Naphthalene	16	B-24	28	11
PCB	0.0018	NA-DP-30	0.043	10
		SB-01509	0.078	7
		NA-DP-21	0.134	10
		NA-DP-29	0.167	
		2-31-DP-08	0.190	
		2-10-DP-073	2.8	

Groundwater				
Constituent	**FMCL µg/L**	**Exceedance Area**	**Concentration µg/L**	**Aquifer Level**
TCE	0.70	cVOC-13	2.2 to 9.0	A-Level
		cVOC-12	3.1	
VC	0.20		0.2 to 1.0	
		cVOC-13	0.4 to 9.2	
Benzene	1.6	BTEX-8	31	
Arsenic	8.0	Arsenic-12	9.0 to 49.8	
		Arsenic-7	10.3	
		Arsenic-8	14.5 and 17.6	
		Arsenic-10	15.4	
		Arsenic-11	1,100	
Copper	8.0	CuZn-17	9.1 and 15.1	
		CuZn-21	10.1 to 60	
Naphthalene	26	DRPH-7	70	
Copper	8.0	CuZn-20	31.2	B-Level
Zinc	56		90	

* Arsenic and chromium are not soil COCs; however arsenic and chromium were detected above the proposed Industrial FMCL at locations PL2-201B and SB-01023, respectively.



NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. RA 8 comprises the Paved Industrial Area, except for those areas included in other RAs.
4. RA 7 comprises the Unpaved Shoreline Area.
5. The Soil Leaching Screening Levels are applied only to soil in the 6-11 feet bgs interval.
6. Several Interim Measures and natural degradation processes are ongoing at the time of this CMS Report submittal; final remedial action designs will be proposed based on current data available at the time of the CMI Work Plan (see Section 6 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC

Wells
- Current EMF Well
- Current Shoreline Monitoring Well
- Current Shoreline Monitoring Well Not Proposed for Future Shoreline Monitoring
- Other Existing Well
- Proposed New Shoreline Monitoring Well
- Proposed Ongoing ERD Injection Well
- Proposed Property Boundary Monitoring Well
- Proposed Upgradient Monitoring Well
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)
- Groundwater Flow Direction
- Cross Section A to A'
- Remediation Area
- Groundwater Exceedance Area
- Planned Soil Excavation Area

Risk Management Areas
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Southwest Bank Corrective Measure Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 200
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

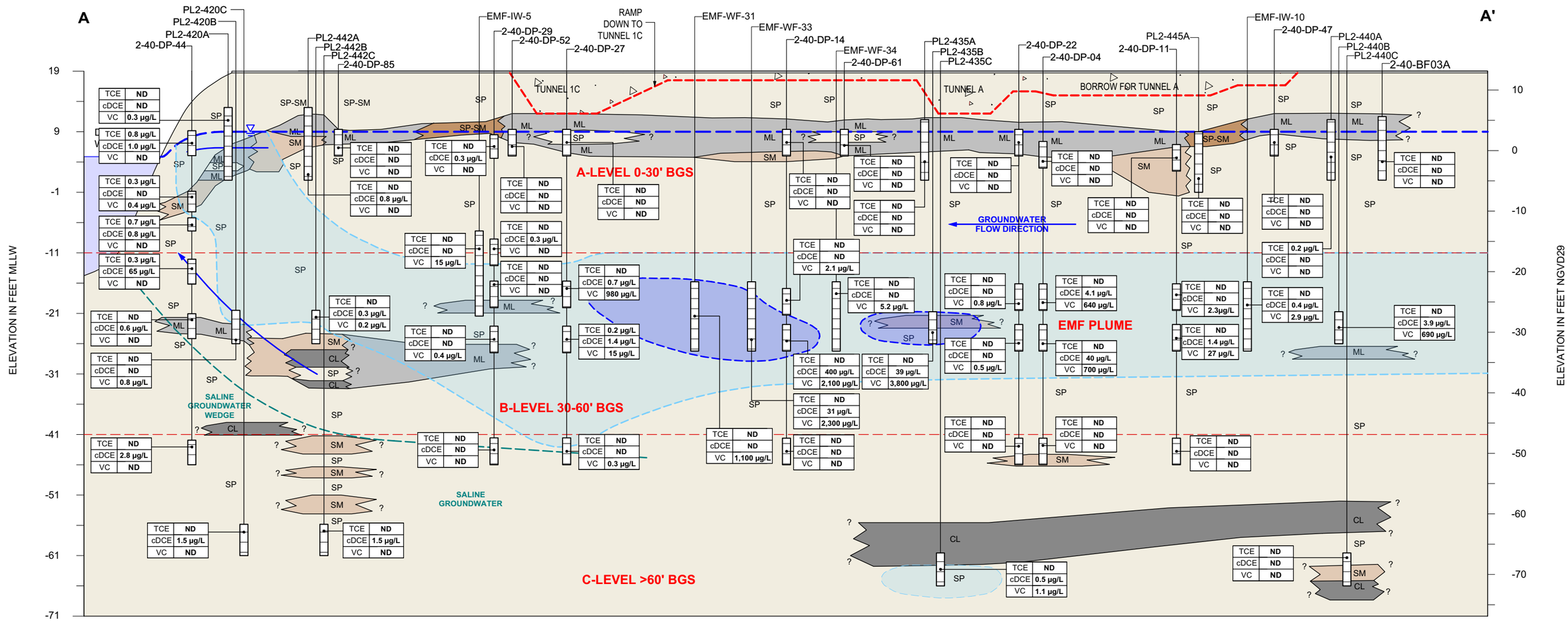
Source:
Golder Associates Inc.

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

FIGURE **6-10B2**
BOEING PLANT 2
RA 8 - PAVED INDUSTRIAL AREA (NORTH)
RECOMMENDED ALTERNATIVE 2
BOEING PLANT 2 CORRECTIVE MEASURES STUDY

Path: G:\Boeing\Plant 2\99_PROJECTS\0131646017_CMS_CONSTRUCTION_SUPPORT\100_CMS_SOB_CMI\02_PRODUCTION\MXD\FIGURES\CMS_Report\Rev0\0131646017_100_074_F_6_10B2_Rev0_NorthIndustrialAreaSoil_RA8.mxd Date: 11/2/2017 User: HJackson

Golder Associates



0 25 50 100

SCALE: 1" = 100'
6X VERTICAL EXAGGERATION

NOTES:

SM	SILTY SAND
SP	POORLY-GRADED SAND
ML	SILT
CL	CLAY OF LOW PLASTICITY, LEAN CLAY
SP-SM	POORLY-GRADED SAND WITH SILT
TCE	TRICHLOROETHENE
cDCE	CIS-1,2-DICHLOROETHENE
VC	VINYL CHLORIDE
ND	NOT DETECTED
NS	NOT SAMPLED
µg/L	MICROGRAMS PER LITER

GROUNDWATER LEVEL

>1,000 µg/L FMCL EXCEEDANCE AREA

<1,000 µg/L FMCL EXCEEDANCE AREA

TUNNEL EXCAVATION BACKFILLED WITH CONCRETE RUBBLE AND SOIL

PL2-218A — MONITORING WELL ID

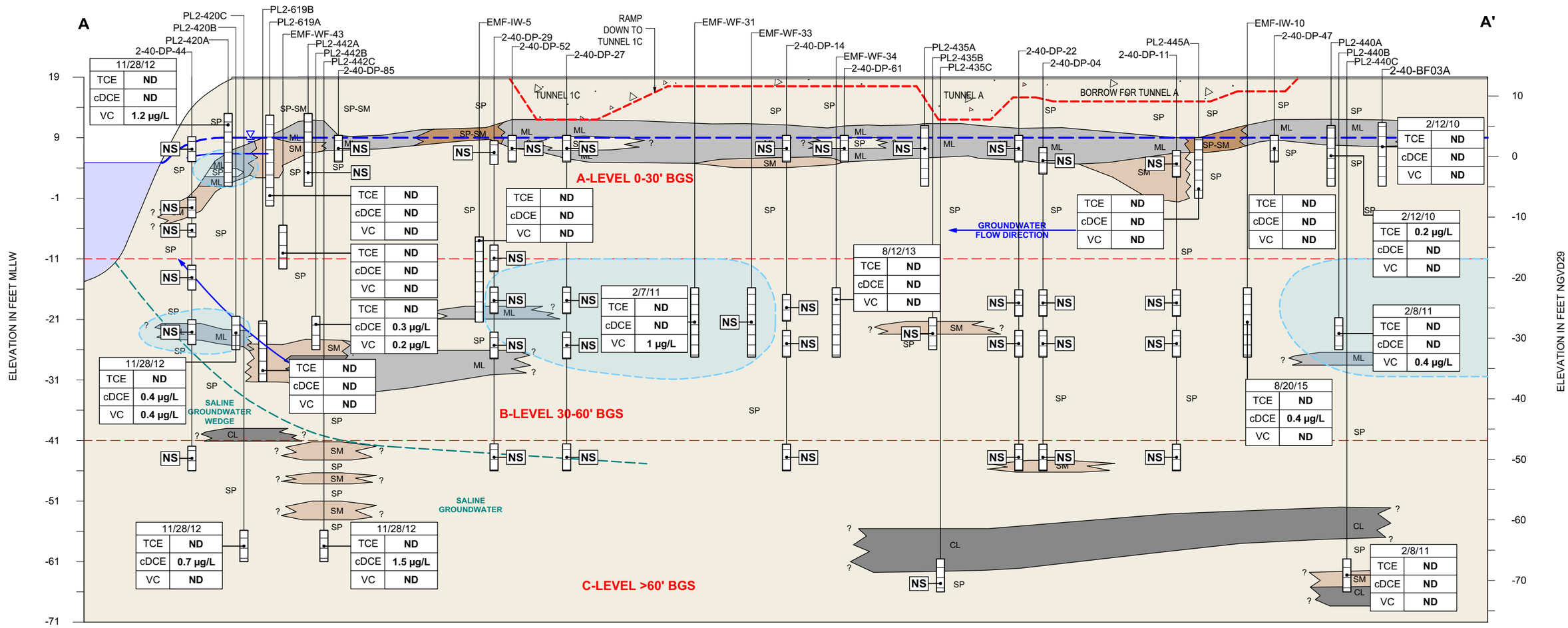
WELL SCREEN

TOTAL WELL DEPTH

FIGURE 6-10C1

RA 8 - PAVED INDUSTRIAL AREA CONCEPTUAL SITE MODEL BASED ON DATA THROUGH JANUARY 2013

PREPARED BY	ENVIRONMENTAL PARTNERS INC		
REPORT	CMS VOLUME X		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILLA WASHINGTON		
PREPARED FOR	THE BOEING COMPANY		
DATE 10/23/17	***DRAWN BY*** VPB	***REVIEWED BY*** DCK	***PROJECT NUMBER*** 17517.0.100.01



0 25 50 100

SCALE: 1" = 100'
6X VERTICAL EXAGGERATION

NOTES:

SM	SILTY SAND
SP	POORLY-GRADED SAND
ML	SILT
CL	CLAY OF LOW PLASTICITY, LEAN CLAY
SP-SM	POORLY-GRADED SAND WITH SILT
TCE	TRICHLOROETHENE
cDCE	CIS-1,2-DICHLOROETHENE
VC	VINYL CHLORIDE
ND	NOT DETECTED
NS	NOT SAMPLED
µg/L	MICROGRAMS PER LITER

GROUNDWATER LEVEL

GROUNDWATER FLOW DIRECTION

<1,000 µg/L FMCL EXCEEDANCE AREA

TUNNEL EXCAVATION BACKFILLED WITH CONCRETE RUBBLE AND SOIL

PL2-218A — MONITORING WELL ID

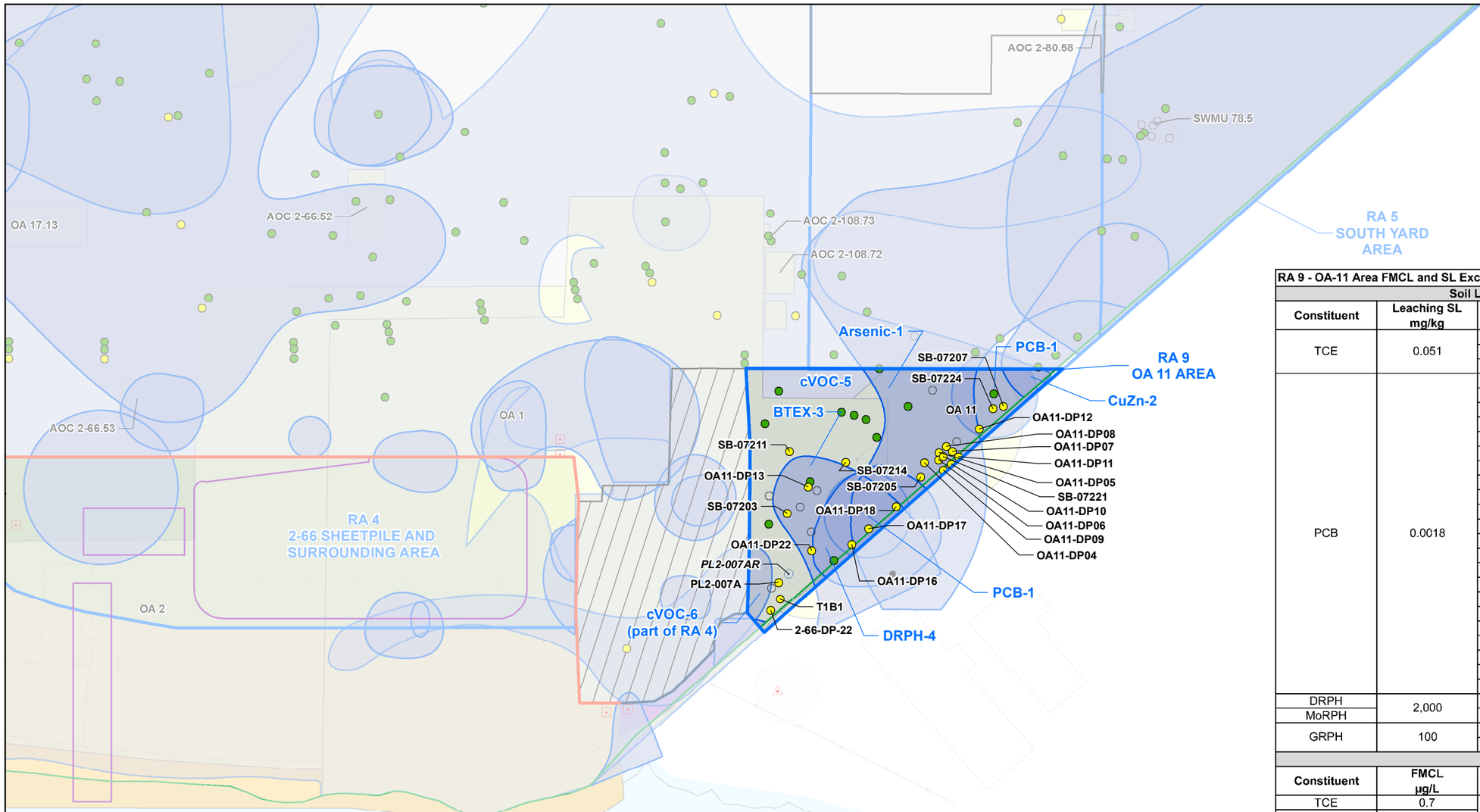
WELL SCREEN

TOTAL WELL DEPTH

FIGURE 6-10C2

RA 8 - PAVED INDUSTRIAL AREA CONCEPTUAL SITE MODEL
ADJUSTED WITH DATA THROUGH DECEMBER 2016 WHERE APPLICABLE

PREPARED BY	ENVIRONMENTAL PARTNERS INC		
REPORT	CMS VOLUME X		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILLA WASHINGTON		
PREPARED FOR	THE BOEING COMPANY		
DATE 10/17/17	***DRAWN BY*** VPB	***REVIEWED BY*** DCK	***PROJECT NUMBER*** 17517.0.100.01



RA 9 - OA-11 Area FMCL and SL Exceedance Locations				
Soil Leaching (6-11 feet bgs)				
Constituent	**Leaching SL mg/kg**	**Soil Sample Location**	**Concentration mg/kg**	**Depth feet bgs**
TCE	0.051	2-66-DP-22	0.11	10
		PL2-007A	0.61	10.3
		SB-07203	1.9	6.5
PCB	0.0018	OA11-DP12	0.0103	8
		OA11-DP06	0.0106	10
		T1B1	0.012	
		SB-07205	0.04	11
		OA11-DP10	0.0406	10
		OA11-DP18	0.0455	8
		OA11-DP04	0.0463	10
		OA11-DP08	0.047	
		OA11-DP05	0.0484	
		OA11-DP09	0.0611	
		SB-07203	0.091	11
		SB-07207	0.23	8
		SB-07211	0.24	
		OA11-DP22	0.253	10
		SB-07224	0.34	11
		OA11-DP13	0.439	10
		SB-07221	0.71	
		SB-07214	2.17	8
		OA11-DP17	2.35	10
		OA11-DP16	6.73	
		OA11-DP11	7.02	
		OA11-DP07	9.94	
DRPH	2,000	OA11-DP16	5000	
MoRPH		OA11-DP16	4930	
GRPH	100	OA11-DP17	554	
		OA11-DP16	1300	
Groundwater				
Constituent	**FMCL µg/L**	**Exceedance Area**	**Concentration µg/L**	**Aquifer Level**
TCE	0.7	cVOC-5	1.0 to 1,100	A-Level
VC	0.2		0.2 to 900	
cDCE	130		312 to 870	
Ethylbenzene	1.7	BTEX-3	310 and 730	
Benzene	1.6		72	
GRPH	Note 5		1,800 and 16,000	
Arsenic	8.0	Arsenic-1	8.2 to 99.8	
Zinc	56	CuZn-2	219 to 305	
MoRPH	Note 5	DRPH-4	1,500	
DRPH			1,100	
Total PCBs	--	PCB-1	0.12 and 0.8	

NOTES
1. The shapes of RCRA units reflect the shapes defined in RFI Report (Weston 1997) and do not reflect recent data, contaminant levels, or unit's NFA status.
2. Proposed FMCLs for the Paved Industrial Areas and the Unpaved Shoreline Areas are different (see CMS Report Section 2).
3. The Soil Leaching Screening Levels are applied only to soil in the 6-11 feet bgs interval.
4. Several Interim Measures and natural degradation processes are ongoing at the time of this CMS Report submittal; final remedial action designs will be proposed based on current data available at the time of the CMI Work Plan (see Section 6 for details).
5. TPH exceedance areas are drawn based on TMCLs; the FMCLs are based on the BTEX and naphthalene constituents (see Section 2 for details).

LEGEND

Cleanup Levels
- Non-detect
- Detected Below Proposed FMCL
- Detected Above Leaching Screening Level
- Detected Above Proposed Shoreline FMCL
- Detected Above Proposed Industrial FMCL
- Detected Above Proposed Industrial FMCL; not a Soil COC

Wells
- Current EMF Well
- Current Shoreline Monitoring Well
- Current Shoreline Monitoring Well Not Proposed for Future Shoreline Monitoring
- Other Existing Well
- Proposed New Shoreline Monitoring Well
- Proposed Property Boundary Monitoring Well
- Proposed Upgradient Monitoring Well
- Paved Industrial/Unpaved Shoreline Separation Line
- Building
- Property Line
- Bridge Alignment
- Sheetpile
- Stormwater Swale
- RCRA Unit (AOC, OA, & SWMU)
- Groundwater Flow Direction
- Cross Section A to A'
- Remediation Area
- Groundwater Exceedance Area

Risk Management Areas
- Unpaved Shoreline Area
- Paved Industrial Area
- Habitat Project Area
- Southwest Bank Corrective Measure Area
- Part of the Jorgensen Forge Outfall Site (CERCLA)

0 60
Scale in Feet

Map Projection:
Washington State Plane North, Feet
NAD 1983

Source:
Golder Associates Inc.

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FIGURE **6-11A**

BOEING PLANT 2
RA 9 - OA 11 AREA
SOIL (0-11 FEET) AND
GROUNDWATER EXCEEDANCE AREAS

BOEING PLANT 2 CORRECTIVE MEASURES STUDY

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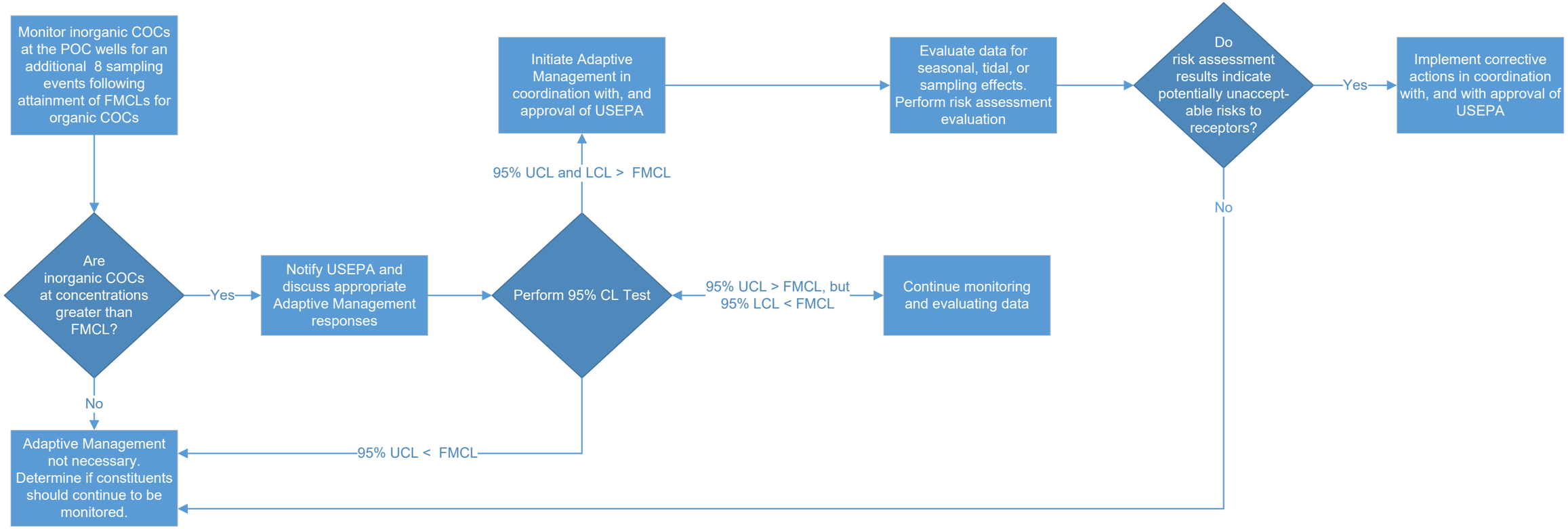

FIGURE 6-12
ADAPTIVE MANAGEMENT FOR INORGANICS IN GROUNDWATER DECISION PROCESS

PREPARED BY	ENVIRONMENTAL PARTNERS INC		
REPORT	UPLANDS CORRECTIVE MEASURES STUDY – VOLUME X: CORRECTIVE MEASURES STUDY REPORT – PLANT 2		
LOCATION	BOEING PLANT 2 7725 EAST MARGINAL WAY, SEATTLE/TUKWILA, WASHINGTON		
PREPARED FOR	THE BOEING COMPANY		
DATE 10/19/2017	*DRAWN BY* CSW	*REVIEWED BY* DK	*PROJECT NUMBER* 17517.0.100.01

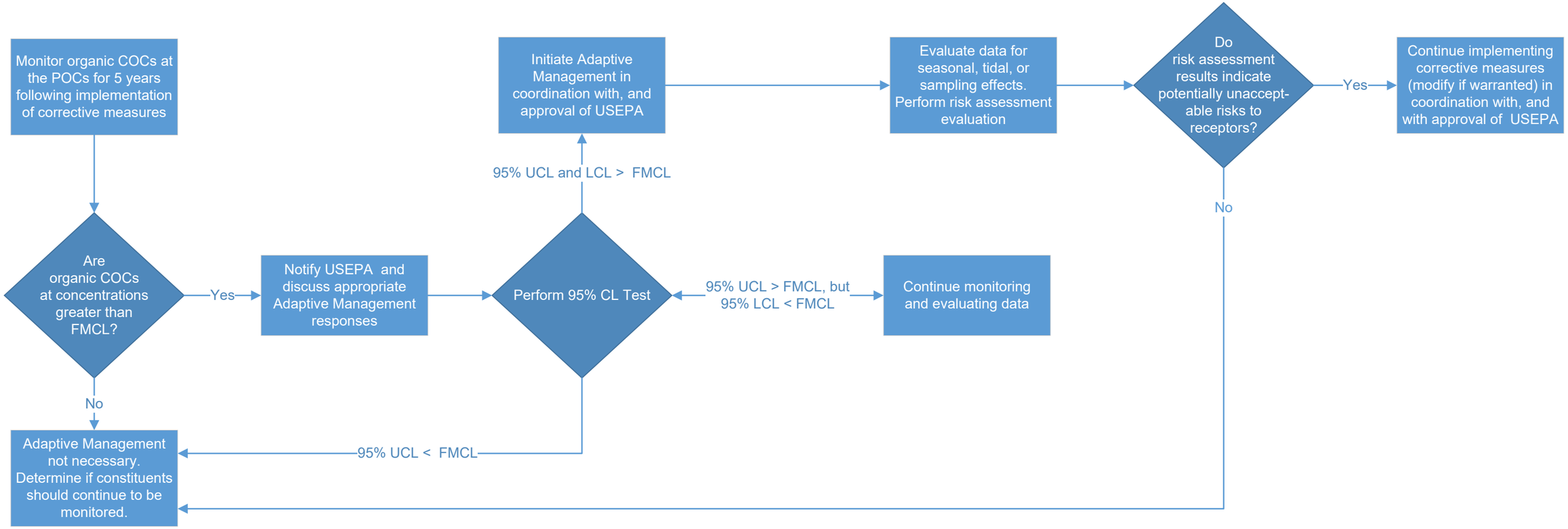

FIGURE 6-13
ADAPTIVE MANAGEMENT FOR ORGANICS IN GROUNDWATER DECISION PROCESS

PREPARED BY	ENVIRONMENTAL PARTNERS INC		
REPORT	UPLANDS CORRECTIVE MEASURES STUDY – VOLUME X: CORRECTIVE MEASURES STUDY REPORT – PLANT 2		
LOCATION	BOEING PLANT 2 7725 EAST MARGINAL WAY, SEATTLE/TUKWILA, WASHINGTON		
PREPARED FOR	THE BOEING COMPANY		
DATE 10/19/2017	*DRAWN BY* CSW	*REVIEWED BY* DK	*PROJECT NUMBER* 17516.0.100.01

Attachments

ATTACHMENT FOREWORD

The attachments to Volume X of the CMS Report are included to 1) provide necessary details that support the discussion in the main body of the text that would have been distracting to the reader if included in the main body, and 2) provide historical documents in electronic format to allow the reader to easily locate information contained in references cited. The following summary is included as a guide to the extensive contents of each section's attachments:

SECTION 1.0

Attachment S1A – Uplands Corrective Measures Study Volumes III through IX

- **Part A - Plant 2 Study Area Data Gap Investigation Work Plans**
- **Part B – Investigation Data Reports**

Volumes IIIa through IXa contain the Plant 2 study area data gap investigation (DGI) work plans. Each work plan provides background information and presents the scope of work and methodology for completing gaps in soil and groundwater data that were required at the time to supplement data and support the remedial alternative recommendation process. Volumes IIIb through IXb are the data reports that present the results of the DGI for each respective study area.

The following list identifies respective Plant 2 study areas and Volumes:

- Volume III Parts a & b, South Yard Area
- Volume IV Parts a & b, 2-60 Area
- Volume V Parts a & b, 2-40s Area
- Volume VI Parts a & b, 2-66 Area
- Volume VII Parts a & b, 2-10 Area
- Volume VIII Parts a & b, 2-31 Area and
- Volume IX Parts a & b, North Area

SECTION 2.0

Attachment S2A - Revisions to the TMCLs contains the *Revision of TMCLs to Incorporate IRIS Toxicity Updates and to Correct Errors in the TMCL Technical Memorandum* (Floyd|Snider revised July 2014), which is supported by:

> Correspondence between Will Ernst and USEPA (Holly Arrigoni) regarding typos and errors in the original TMCL document, and
>
> Memorandum *OEA Recommendations Regarding Trichloroethylene Toxicity in Human Health Assessments* (USEPA 2012).

Attachment S2B - Analytical Considerations for Groundwater Compliance contains the Memorandum *Specialized Analytical Considerations for Evaluation of Compliance with Groundwater TMCLs* (Floyd |Snider July 2014).

Attachment S2C - Background Considerations provides a written response to USEPA Comments of February 23, 2006 regarding *Technical Memorandum: Development and Use of Background Values* and a copy of the revised document dated March 30, 2006, which is supported by:

Technical Memorandum Development of Proposed Soil cPAH FMCLs Including Consideration of Urban Background Concentrations (Floyd|Snider 2014)

Attachment S2D - PQL Considerations contains the Memorandum *Groundwater Monitoring Compliance for Constituents with Risk Based Criteria Lower than the Practical Quantitation Limit* (Floyd|Snider June 2014)

Attachment S2E – Draft Environmental Covenant with Anticipated Language provides an example of the draft Environmental Covenant (EC) text that will be coordinated between USEPA and Boeing. The EC is not ready for formal submittal and is included as a draft (not for comment) in Volume X, but will be completed upon completion of the SOB.

SECTION 3.0

Attachment S3A – Soil Interim Measures and Construction Projects Documentation for Table 3-1 provides electronic copies of the documents cited in Table 3-1 in order presented in the "Soil Excavation ID" column of the table.

Attachment S3B1 – Table S3B-1 Sample Locations Representative of Plant 2 Soils Relocated for Use as Backfill in the 2-40s Area Demolition/Redevelopment Project identifies soil sample locations collected as part of the 2010-2012 2-31, 2-40s, and 2-60s Demolition/Redevelopment project. Relocated soil placements are presented in Figure 3-3.

Attachment S3B2 - Table S3B-2 Crushed Concrete Backfill Analytical Data Summary 2-31, 2-40s, and 2-60s Demolition/Redevelopment Areas provides the analytical results for crushed concrete samples used as backfill during the 2010-2012 2-31, 2-40s, and 2-60s Demolition/Redevelopment project subject to the associated TSCA RBDA. Crushed concrete sample locations are presented in Figure 3-4.

Attachment S3B3 and S3B4 provides the analytical data representative of soil imported by contractors for use as backfill for the 2010-2012 2-31, 2-40s, and 2-60s Demolition/Redevelopment project. Imported soil placement locations are presented in Figure 3-3.

Attachment S3C1 – Plant 2 Groundwater Interim Measures Descriptions provides a summary of the groundwater interim measures performed at Plant 2 independently or in conjunction with the 2010-2012 2-31, 2-40s, and 2-60s Demolition/Redevelopment project.

Attachment S3C2 - Groundwater Interim Measures Documentation for Table 3-2 provides electronic copies of the documents cited in Table 3-2 in the order listed in the "Associated Documentation" column of the table.

SECTION 4.0

Attachment S4A – Soil Data Tables present soil data by constituent generated post-DGI, August 30, 2010 through December 31, 2016, as the cut off for soil data used in this document. Data prior to August 2010 are contained in Volumes III through IX of the CMS Report referenced above.

Attachment S4B1 Data Gap Investigation Groundwater Data Replacement Instances identifies the specific instances in which DGI groundwater data were replaced with more recent data.

Attachment S4B2 Groundwater COC Maps provides figures that present groundwater data by constituent based on DGI data, with the exception of the specific instances identified in Attachment S4B1.

SECTION 5.0

Attachment S5A1, Federal Remediation Technologies Roundtable (FRTR) Treatment Technology Screening Matrix presents treatment technologies for six classification groups of COCs (which are similar to but not identical to the Plant 2 COC groups) and rates them. Technologies rated as average or above average for one or more of the Plant 2 COC groups were retained for further evaluation.

Attachment S5A2, Table S5A2 Treatment Technology Screening Matrix Contaminant Classifications Linked to Plant 2 COPC Groups lists the Plant 2 COPC groupings and individual COCs included in each grouping, and indicates where they fit within the six applicable FRTR contaminant classifications.

Attachment S5A3, Potential Remedial Technology Summary provides descriptions of the remedial technologies rated as "average" or above average" for the soil and groundwater COCs at Plant 2 and identifies whether the technology was retained for further evaluation in assembling alternatives in Section 6.

SECTION 6.0

Attachment S6A1, Well Network and Monitoring Program Descriptions provides a description of the proposed Plant 2 monitoring well network and the purpose of each class of well. Attachment S6A1 includes three tables:

1. S6A1-1: Proposed Plant 2 Shoreline Monitoring Well Network Summary
2. S6A1-2: Proposed Plant 2 Upgradient Monitoring Well Network Summary
3. S6A1-3: Proposed Plant 2 Property Boundary Monitoring Well Network Summary

The tables provide details for the individual wells in each of the three primary classes of monitoring wells. A figure presenting the monitoring well locations is also provided in Attachment S6A1.

Attachment S6B, CMI Phase Monitoring Well Installation Work Plan presents groundwater conditions at Plant 2 and identifies the proposed locations of replacement monitoring wells decommissioned in association with the 2-31, 2-40s, and 2-60s Demolition/Redevelopment project, other various construction projects and damaged wells, and identifies new monitoring network wells. In addition, the well specifications for installation of the wells are provided in the work plan. Boeing has partially completed the scope of work outlined in the work plan and will complete the scope of work based on finalization of the SOB.

Attachment S6C, RCRA Remedial Alternative Evaluation Standards and Alternative Evaluation defines the RCRA standards used to evaluate the corrective measure alternatives for Remediation Areas RA 1 through RA 8 and provides details of the remedial alternative evaluation for each RA subject to the process outlined in Section 6.5.

Attachment S6D, Alternative Cost Estimates presents the cost estimates for values used in the remedial alternative evaluations presented in Section 6 and Attachment S6C.