Lower Duwamish Waterway
RM 4.3 to 4.9 East
(Boeing Developmental Center)

Summary of Existing Information and Identification of Data Gaps

Prepared for

DEPARTMENT OF
ECOLOGY
State of Washington

Toxics Cleanup Program
Northwest Regional Office
Washington State Department of Ecology
Bellevue, Washington

Prepared by

SAIC
From Science to Solutions

Science Applications International Corporation
18912 North Creek Parkway, Suite 101
Bothell, WA 98011

September 2010

Table of Contents

Tables

Figures

Appendices

Acronyms and Abbreviations

AOC	Area of Concern
BDC	Boeing Developmental Center
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
COC	chemical of concern
CSCSL	Confirmed or Suspected Contaminated Sites List
CSL	Cleanup Screening Level
CSO	combined sewer overflow
DW	dry weight
E&E	Ecology & Environment, Inc.
EAA	Early Action Area
ECHO	Enforcement and Compliance History Online
Ecology	Washington State Department of Ecology
EOF	emergency overflow
EPA	U.S. Environmental Protection Agency
GIS	Geographic Information Systems
HAP	Hazardous Air Pollutant
HazMat	Hazardous Materials
ISIS	Integrated Site Information System
KCIA	King County International Airport
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
LUST	leaking underground storage tank
mg/kg	milligrams per kilogram
MFC	Military Flight Center
MOF	Museum of Flight
MOU	Memorandum of Understanding
MTCA	Model Toxics Control Act
NOAA	National Oceanic and Atmospheric Administration
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NWRO	Northwest Regional Office
OC	organic carbon
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PSCAA	Puget Sound Clean Air Agency
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
RM	River Mile
SAIC	Science Applications International Corporation
SCAP	Source Control Action Plan
SCL	Seattle City Light
SD	storm drain

SIC	Standard Industrial Classification
SMS	Sediment Management Standards
SPU	Seattle Public Utilities
SQS	Sediment Quality Standard
SVOC	semivolatile organic compound
SWMU	solid waste management unit
SWPPP	Stormwater Pollution Prevention Plan
TCE	trichloroethene
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TSS	total suspended solids
UST	underground storage tank
VCP	Voluntary Cleanup Program
VOC	volatile organic compound
WAC	Washington Administrative Code
WWTP	wastewater treatment plant
μg/L	micrograms per liter

1.0 Introduction

1.1 Background and Purpose

This *Summary of Existing Information and Identification of Data Gaps* report (Data Gaps Report) pertains to River Mile (RM) 4.3-4.9 East[1] (Boeing Developmental Center), one of 24 source control areas identified as part of the overall cleanup process for the Lower Duwamish Waterway (LDW) Superfund Site (Figure 1). It summarizes readily available information regarding properties in the Boeing Developmental Center (BDC) source control area. Part of the northern portion of the BDC was included in the Data Gaps Report (E&E 2008) and Source Control Action Plan (SCAP) (Ecology 2008b) for the RM 3.9 to 4.3 East (Slip 6) source control area. Part of the southern portion of the BDC was included in the Data Gaps Report (E&E 2007) and SCAP (Ecology 2007b) for the RM 4.9 East (Norfolk Combined Sewer Overflow [CSO]/storm drain [SD])[2] source control area.

The purpose of this Data Gaps Report is to:

- Identify chemicals of potential concern in sediments associated with the BDC source control area;
- Evaluate potential contaminant migration pathways to LDW sediments;
- Identify and describe potential adjacent or upland sources of contaminants that could be transported to sediments;
- Identify critical data gaps that should be addressed to assess the potential for recontamination of sediments and the need for source control; and
- Determine what, if any, effective source control is already in place.

The LDW consists of 5.5 miles of the Duwamish Waterway, as measured from the southern tip of Harbor Island to just south of the Norfolk CSO. The LDW flows into Elliott Bay in Seattle, Washington. The LDW was added to the U.S. Environmental Protection Agency (USEPA or EPA) National Priorities List in September 2001 due to the presence of chemical contaminants in sediment. The key parties involved in the LDW site are EPA, the Washington State Department of Ecology (Ecology), and the Lower Duwamish Waterway Group (LDWG), which is composed of the City of Seattle, King County, the Port of Seattle, and The Boeing Company. In December 2000, EPA and Ecology signed an agreement with the LDWG to conduct a Remedial Investigation/Feasibility Study (RI/FS) for the LDW site.

EPA is leading the effort to determine the most effective cleanup strategies for the LDW through the RI/FS process. Ecology is leading the effort to investigate upland sources of contamination and to develop plans to reduce contaminant migration to waterway sediments.[3] The LDWG collected data during a Phase 1 Remedial Investigation (RI) (Windward 2003) that were used to

---

[1] River miles as defined in this report are measured from the southern tip of Harbor Island.
[2] The RM 4.9 East (Norfolk CSO/SD) source control area is also referred to as Early Action Area 7 (EAA-7).
[3] EPA and Ecology signed an interagency Memorandum of Understanding (MOU) in April 2002 and updated the MOU in April 2004. The MOU divides responsibilities for the site. EPA is the lead agency for the sediment RI/FS, while Ecology is the lead agency for source control issues (EPA and Ecology 2002, 2004).

identify candidate locations for early cleanup action. Seven candidate early action sites (or Tier 1 sites) were identified. Part of the BDC is located within one of these Tier 1 sites (Norfolk CSO/SD). Ecology's *Lower Duwamish Waterway Source Control Status Report, 2003 to June 2007* (Ecology 2007a) and *Lower Duwamish Waterway Source Control Status Report, July 2007 to March 2008* (Ecology 2008a) identified another 16 areas where source control actions may be necessary[4]. The BDC source control area was identified as one of these areas. Subsequently, Ecology and EPA redefined the boundaries of the source control areas, generally defined by stormwater drainage basins.

Ecology is the lead agency for source control for the LDW site. Source control is the process of finding and eliminating or reducing releases of contaminants to LDW sediments, to the extent practicable. The goal of source control is to prevent sediments from being recontaminated after cleanup has been undertaken.

The LDW Source Control Strategy (Ecology 2004) describes the process for identifying source control issues and implementing effective controls for the LDW. The plan is to identify and manage potential sources of sediment recontamination in coordination with sediment cleanups. Source control will be achieved by using existing administrative and legal authorities to perform inspections and require necessary source control actions.

The strategy is based primarily on the principles of source control for sediment sites described in EPA's *Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites* (EPA 2002), and the Washington State Sediment Management Standards (SMS) (Washington Administrative Code [WAC] 173-340-370[7] and WAC 173-204-400). The Source Control Strategy involves developing and implementing a series of detailed, area-specific SCAPs.

Before developing a SCAP, Ecology prepares a Data Gaps Report for the source control area. Findings from the Data Gaps Report are reviewed by LDW stakeholders and are incorporated into the SCAP. This process helps to ensure that the action items identified in the SCAP will be effective, implementable, and enforceable. As part of the source control efforts for the BDC source control area, Ecology requested Science Applications International Corporation (SAIC) to prepare this Data Gaps Report.

1.2 Report Organization

Section 2 of this report provides background information on the BDC source control area, including location, physical characteristics, chemicals of concern (COCs), and pathways by which contaminants may reach sediments. Sections 3 and 4 describe potential sources of contaminants and data gaps that must be addressed in order to minimize the potential for LDW sediment recontamination. Section 5 provides a summary of data gaps, and Section 6 lists the documents reviewed during preparation of this report.

Information presented in this report was obtained from the following sources:

- Ecology Northwest Regional Office (NWRO) Central Records;

[4] One additional source control area was added by Ecology in 2010, for a total of 24 source control areas.

- Washington State Archives;
- Ecology Underground Storage Tank (UST) and Leaking Underground Storage Tank (LUST) lists;
- Ecology Facility/Site Database;
- Ecology Integrated Site Information System (ISIS) Database;
- Washington Confirmed and Suspected Contaminated Sites List (CSCSL);
- EPA Enforcement and Compliance History Online (ECHO);
- EPA Envirofacts Warehouse;
- King County Geographic Information Systems (GIS) Center Parcel Viewer, Property Tax Records, and iMap; and
- Historical aerial photographs.

Information collected from the Facility/Site Database, ISIS, ECHO, EPA Envirofacts Warehouse, and King County property tax records was current as of June 2010. Recent updates to these databases may not be reflected in this report.

1.3 Scope of Report

This report documents readily available information relevant to potential sources of contaminants to sediments associated with the BDC source control area, including outfalls and adjacent properties, not assessed as part of the previously completed Data Gaps Reports and SCAPs.

Information presented in this report is limited to the BDC source control area, direct discharges to the sediments associated with the source control area, and potential adjacent and upland contaminant sources. Source control with regard to any contaminated sediments removed or left in place during cleanup in this portion of the LDW will need to be addressed as part of the remedial action decision and design for this area.

Chemical data have been compared to relevant regulatory criteria and guidelines, as appropriate. The level of assessment conducted for the data reviewed in this report is determined by the source control objectives. The scope of this Data Gaps Report does not include data validation or analysis that exceeds what is required to reasonably achieve source control.

Air pollution is a potential source of sediment contamination with origins outside of the BDC source control area. Although limited discussion of atmospheric deposition is provided in Section 2, the scope of this report does not include an assessment of data gaps pertaining to the effects of air pollution on the sediments associated with the source control area. Because air pollution is a concern for the wider LDW region, Ecology will review work being conducted by the Washington State Department of Health and planned by the Puget Sound Partnership regarding atmospheric deposition.

This page intentionally left blank.

2.0 BDC Source Control Area

The BDC source control area (also referred to as the RM 4.3-4.9 East source control area) is located along the eastern side of the LDW Site between RM 4.3 and 4.9, as measured from the southern end of Harbor Island (Figure 1). In this source control area (Figure 2), only one facility (BDC) is located directly adjacent to the LDW. Stormwater from the BDC property drains to one of three areas: Slip 6, RM 4.3 East to the Boeing Pedestrian Bridge, and the area around RM 4.9 East. The area draining to Slip 6 and the area around RM 4.9 East were addressed in earlier source control reports, as described in Section 2.1 below. For purposes of this report, "BDC source control area" refers to the portions of the BDC facility that drain to the area between RM 4.3 East and the Boeing Pedestrian Bridge, as shown in Figures 2 and 3. This is different than "BDC property" which refers to the entire facility, including those portions evaluated in other source control reports.

To the east of the BDC source control area are the King County Museum of Flight (MOF), King County International Airport (KCIA), and the Boeing Military Flight Center (MFC).

To the north of the BDC source control area are portions of the BDC property from which stormwater drains to Slip 6, and the former Rhone-Poulenc property, which is now owned by Container Properties, LLC. These facilities were discussed in the Data Gaps Report and SCAP for the Slip 6 (RM 3.9-4.3 East) source control area (E&E 2008; Ecology 2008b).

To the south of the BDC source control area are portions of the BDC property from which stormwater drains to the area near RM 4.9 East (including the BDC south storm drain) and a vacant lot, identified as "Strick Lease Storage Yard" in King County property records. Aerial photos indicate that the lot may be used to store truck/train trailers. This portion of the BDC property was discussed in the Data Gaps Report and SCAP for the Norfolk CSO/SD (RM 4.9 East) source control area (E&E 2007; Ecology 2007b). The vacant lot was not discussed in the Norfolk CSO/SD source control reports.

2.1 Summary of Previous Data Gaps Reports

Portions of the BDC property have been included in earlier Data Gaps Reports and SCAPs. At the time that the Data Gaps Report for the Norfolk CSO/SD (RM 4.9 East) was prepared, seven candidate EAAs had been identified, and the area around the Norfolk CSO/SD was identified as EAA-7. Since then, early actions have been planned or undertaken for only five of those original seven areas. When citing the Data Gaps Report for the Norfolk CSO/SD, it will be referred to by its original report name (EAA-7 Data Gaps Report).

Relevant information from previous Data Gaps Reports is summarized below; these areas of the BDC are not addressed further in the current Data Gaps Report, except as they directly relate to the BDC source control area (Figure 2).

2.1.1 EAA-7 (Norfolk CSO/SD) Data Gaps Report and SCAP

The EAA-7 Data Gaps Report summarized available information about the area of the property that drains to the following five SD outfalls, located between S 102nd Street Bridge and the Boeing pedestrian bridge (Figure 2):

LDW RI Outfall No.[1]	Boeing Outfall No.	Description[2]	Pipe Diameter/ Material	Outfall Discharge Volume[3]
2095	DC1	Stormwater from parking areas and roadways in the southernmost portion of the BDC property; discharges through an oil/water separator to the 84-inch King County/SPU Norfolk CSO/SD at a point just upstream of the outfall. This outfall also includes drainage from the 769-acre Norfolk SD basin and the 4,900-acre Norfolk CSO basin.	84-inch (6 ft x 6 ft)	Very Large
2093	DC2	Also referred to as the South SD; collects stormwater runoff from the roof of Building 9-110 and a portion of the roof of Building 9-101, and from parking areas and roadways adjacent to these buildings. Stormwater is collected into a primary SD line, which runs through part of the south end of the BDC property before it discharges via a 24-inch concrete pipe to the LDW. A sediment trap / oil/water separator was installed in this drain upstream of manhole MH2 in 2003.	24-inch concrete	Large
2096	DC3	Drains a portion of the roofs of Buildings 9-140 and 9-130, plus the pavement and planted areas around this part of the building, and a small landscaped area for employee use.	6-inch iron	Small
BDC-5	DC16	Drains the southwest corner of the Building 9-140 roof and the pavement and planted areas around this part of the building.	No information	Very Small
2097	DC4	Also drains a small portion of the Building 9-140 roof and pavement/plantings near this building.	8-inch steel	Very Small
2092	DC17	Drains the southwest corner of the Building 9-101 roof, and approximately half of the roof areas of Buildings 9-140 and 9-130, plus the parking and roadway areas around portions of these buildings.	18-inch iron	Small

1. Outfall number as listed in Windward 2010, Appendix H.
2. Sources: Ecology 2007b; Windward 2010; Boeing 2003; Bet 2009; Herrera 2004
3. Outfall discharge volumes are presented as listed in Boeing 2010a; no definitions are provided.

In addition, an unidentified 12-inch concrete outfall pipe (Outfall 2094) was observed during surveys conducted in support of the LDW Phase 2 RI (Windward 2010). This outfall is not shown on Boeing drainage maps and was not discussed in the EAA-7 Data Gaps Report or SCAP. According to Boeing, this outfall is closed and there is no discharge from this outfall; it was approximately half full with sand in 2003, and this sand currently remains in place (Boeing 2010b).

In 2001, polychlorinated biphenyls (PCBs) were detected in the South SD line at concentrations up to 16,700 mg/kg dry weight (DW). Boeing conducted pressure cleaning of approximately 500 meters of the South SD piping in 2002 to remove PCBs from the interior of the SD piping. High levels of PCBs were found in the sidewall scum/organic material found on pipe interiors along the older SD segments. In 2003, Boeing installed a sediment trap / oil/water separator (Vortechnics 9000 unit) in the South SD line as a source control measure to help prevent stormwater solids from reaching the LDW. Subsequently, in September 2003, Boeing removed sediment in the LDW immediately offshore of the South SD line outfall and approximately 130 feet downstream of the Norfolk CSO/SD outfall (DC1), under Ecology's Voluntary Cleanup Program (VCP). A permeable carbon fabric was then placed in the excavation, and the excavation was backfilled with clean sand.

As described in the August 2009 Source Control Status Report (Ecology 2009a), Boeing's contractor (Calibre Systems) published a *Summary of Storm Drain Line Cleanout Work and 2008 Annual Sampling Report, South Storm Drain System, Boeing Developmental Center* (Calibre 2009), which presented results of the post-removal monitoring associated with the South SD system and documents additional cleaning performed in a segment of the SD system beneath Building 9-101 during 2008.

Additional information is provided in the EAA-7 Data Gaps Report and SCAP, and in the LDW Source Control Status Reports (Ecology 2007a; Ecology 2008a; Ecology 2008c; Ecology 2009a; and subsequent updates).

2.1.2 Slip 6 Data Gaps Report and SCAP

The Slip 6 (RM 3.9-4.3 East) Data Gaps Report includes the northern portion of the BDC property, and a parcel to the north/northeast that was formerly part of the BDC property and is currently owned by the MOF. Groundwater investigations at the MOF (former BDC) parcel (Parcel 1034 as shown on Figure 3) found diesel-range and gasoline-range petroleum hydrocarbons; however, the source and extent of groundwater contamination is unknown. This was identified as a data gap for the Slip 6 source control area. Recommended source control actions included continued monitoring of stormwater and/or SD solids at the MOF (former BDC) parcel in the vicinity of USTs and groundwater contamination; development of a plan to remove the USTs and associated soil and groundwater contamination; identify the source and extent of groundwater contamination on the parcel; and conduct remedial actions, if necessary (Ecology 2008b).

The areas of the BDC property with stormwater and surface drainage north to Slip 6 were also included in the Slip 6 Data Gaps Report and SCAP. Two stormwater outfalls currently discharge from the BDC to Slip 6:

LDW RI Outfall No.[1]	Boeing Outfall No.	Description[2]	Pipe Diameter/ Material	Outfall Discharge Volume[3]
2081	DC15	Drains most of the roof of Buildings 9-77, 9-05, and 9-07; a large water storage tank; and extensive parking and paved storage areas. Runoff collected in this SD line passes through an oil/water separator prior to discharge. Also discharges stormwater drainage from the MOF (former BDC) parcel.	36-inch concrete	Medium
2082	DC14	Drains the roof of the northern half of Building 9-08, large paved parking and roadway areas around the building; planted areas; and a greenbelt corridor on the western property boundary, adjacent to the LDW. Runoff	24-inch steel	Medium

LDW RI Outfall No.[1]	Boeing Outfall No.	Description[2]	Pipe Diameter/ Material	Outfall Discharge Volume[3]
		collected in this SD line passes through an oil/water separator prior to discharge.		

1. Outfall number as listed in Windward 2010, Appendix H.
2. Sources: Ecology 2007b; Windward 2010; Boeing 2003; Bet 2009; Herrera 2004.
3. Outfall discharge volumes are presented as listed in Boeing 2010a; no definitions are provided.

Two additional pipes were observed in this area during an outfall survey conducted by Seattle Public Utilities (SPU) in 2003 (Herrera 2004). These are shown as abandoned outfalls 2083 and 2084 in Figure 2. An investigation conducted by Boeing identified these as hydraulic pressure relief pipes which drain infiltrated tidal waters from behind the bulkhead. They are therefore part of the original bulkhead design, and are not outfalls.

The Slip 6 Data Gaps Report (E&E 2008) indicated that stormwater from Building 9-04 at the MOF property appeared to discharge to Outfall DC9 (2090). However, the most recent stormwater drainage map (Boeing 2009c) shows that stormwater drainage from the portion of the MOF property that includes Building 9-04, and the parking areas to the northwest, is discharged via Outfall DC15 to Slip 6 (Figure 5).

According to the Slip 6 SCAP (Ecology 2008b), no sampling of stormwater in this drainage area has been conducted, and it not known whether stormwater or SD solids may represent a potential source of sediment recontamination. In addition, no information was available regarding the potential presence of USTs in this area. These were identified as data gaps. Recommended source control actions included stormwater and/or SD solids sampling in the DC14/DC15 drainage area, and investigation of any USTs that may be located within this area.

Additional information is provided in the Slip 6 Data Gaps Report and SCAP (E&E 2008; Ecology 2008b), and updates will be provided in future LDW Source Control Status Reports.

2.2 Site Description

General background information on the LDW is provided in the Phase 1 RI Report (Windward 2003), which describes the history of dredging/filling and industrialization of the Duwamish River and its environs, as well as the physiography, physical characteristics, hydrogeology, and hydrology of the area.

The upland areas adjacent to the LDW have been industrialized for many decades; historical and current commercial and industrial operations in the vicinity of BDC include a commercial airport, chemical manufacturing, a military flight center, a museum, and an auto wrecking storage yard.

In the late 1800s and early 1900s, extensive topographic modifications were made to the Duwamish River to create a straightened channel; many of the current side slips are remnants of old river meanders. Slip 6, which is immediately north of the BDC property, is one of these remnants.

Groundwater in the Duwamish Valley alluvium is typically encountered within about 3 meters (10 feet) of the ground surface and under unconfined conditions (Windward 2003). The general direction of groundwater flow is toward the LDW, although the direction may vary locally depending on the nature of the subsurface material, and temporally, based on proximity to the LDW and the influence of tidal action. High tides can cause temporary groundwater flow reversals, generally within 100 to 150 meters (300 to 500 feet) of the LDW (Booth and Herman 1998). Groundwater flow in the vicinity of the BDC source control area is generally to the southwest, toward the LDW.

Bottom sediment composition is variable throughout the LDW, ranging from sands to mud. Typically, the sediment consists of slightly sandy silt with varying amounts of organic detritus. Coarser sediments are present in nearshore areas adjacent to SD discharges (Weston 1999); finer-grained sediments are typically located in remnant mudflats and along channel side slopes. LDW sediments in the vicinity of the BDC source control area range from >80 percent fines near Slip 6 to 40 to 60 percent fines at the upstream end of the source control area, with isolated patches of finer and coarser material (Windward 2003).

Ten active private outfalls, one abandoned outfall, and four seeps are present along the shoreline in the BDC source control area (Figure 2).

2.3 Chemicals of Concern in Sediment

In 1999, King County dredged sediments in the area offshore of the Norfolk CSO/SD outfall (located around RM 4.9 East), and backfilled the dredged area with clean sand. Following the cleanup, King County initiated a 5-year sampling program to monitor the sediment cap for potential recontamination by metals and organic contaminants. Sediment data associated with monitoring of the cap, and data from other studies associated with the RM 4.9 East source control area, are described in the EAA-7 Data Gaps Report (E&E 2007).

Chemicals detected in LDW sediment samples collected in the river segment near the BDC source control area (i.e., between RM 4.3 and 4.9 East) are listed in Appendix A. Surface sediment sample locations within this area are summarized in Table 1. No subsurface sediment samples have been collected in this area (except in the LDW navigation channel). Chemical detections exceeding the Washington State SMS are summarized in Table 2. Sampling locations and SMS exceedances are shown in Figure 4.

Laboratory detection limits exceeded the Sediment Quality Standards (SQS) for three chemicals that were not detected in any of the sediment samples collected near RM 4.3-4.9 East: hexachlorobutadiene, 1,2,4-trichlorobenzene, and N-nitrosodiphenylamine. These chemicals may or may not be present in sediment at concentrations exceeding the SQS.

2.3.1 Sediment Investigations

Sediment samples have been collected from the area near RM 4.3-4.9 East as part of the following investigations.

- **Boeing Site Characterization (October 1997)**

  Twenty-two surface sediment samples were collected by Boeing in the vicinity of the BDC source control area in October 1997. Samples were analyzed for polycyclic aromatic hydrocarbons (PAHs), PCBs, metals and trace elements, phthalates, and semivolatile organic compounds (SVOCs) including chlorinated benzenes and phenols (Exponent 1998, as cited in Windward 2003). Chemicals detected at these sample locations are listed in Appendix A.

- **Duwamish Waterway (NOAA) Sediment Characterization Study (September-November 1997)**

  Twenty-four surface sediment samples were collected near the BDC source control area. These samples were analyzed for PCBs (NOAA 1998). PCBs were detected in all samples, with concentrations ranging from 0.002 to 0.087 mg/kg DW.

- **EPA Site Inspection, Lower Duwamish River (August 1998)**

  Twelve surface sediment samples were collected in the vicinity of the BDC source control area in August 1998. Samples were analyzed for volatile organic compounds (VOCs), SVOCs, metals, PCBs as Aroclors and congeners, dioxins/furans, and total organic carbon (TOC) (Weston 1999). Chemicals detected at these sample locations are listed in Appendix A. No subsurface samples were collected in this area.

- **LDW Remedial Investigation Benthic Sampling (August 2004)**

  One surface sediment sample (B9a) was collected by Windward in the vicinity of RM 4.5 East (Figure 4) in August 2004. The sample was analyzed for total PCBs, PAHs, pesticides, metals, and SVOCs (Windward 2006). Chemicals detected at this sample location are listed in Appendix A.

- **LDW Phase 2 Remedial Investigation, Round 1 and 2 Surface Sediment Sampling (January to March 2005)**

  Four surface sediment samples were collected by Windward near the BDC source control area during Rounds 1 and 2 of the LDW Phase 2 RI during January to March 2005. All samples were analyzed for the SMS list of chemicals, SVOCs, and PCBs as Aroclors and congeners (Windward 2005a, 2005b). A subset of samples was also analyzed for polychlorinated dioxins and furans. Chemicals detected at these sampling locations are listed in Appendix A.

2.3.2 Identification of Chemicals of Concern

A chemical of concern (COC) is defined in this report as a chemical that is present in RM 4.3-4.9 East sediments at concentrations above regulatory criteria, and is therefore of particular interest with respect to source control. These COCs are the initial focus of the evaluation of potential contaminant sources.

The Washington SMS (Chapter 173-204 WAC) establish marine Sediment Quality Standard (SQS) and Cleanup Screening Level (CSL) values for some chemicals that may be present in sediments. The SQS values correspond to a sediment quality level that will result in no adverse effects on biological resources and no significant human health risk. CSLs represent minor adverse effects levels and are used as an upper regulatory threshold for making decisions about source control and cleanup.

A chemical was identified as a COC for RM 4.3-4.9 East if it was detected in sediment at concentrations above the SQS. A comparison of sample results to the SQS and CSL values is provided in Appendix A, and those chemicals that were detected at concentrations above their respective SQS/CSL values are listed in Table 2. For non-polar organics, the dry weight concentrations were organic carbon (OC) normalized to allow comparison to the SQS/CSL.

Chemicals detected in sediment for which no SQS/CSL values are available may be identified as COCs on a case-by-case basis. Additional contaminants may be present in soil, groundwater, stormwater, or stormwater solids at concentrations above regulatory criteria and/or soil-to-sediment or groundwater-to-sediment screening levels (SAIC 2006). These screening levels were developed to assist in the identification of upland properties that may pose a risk of recontamination of sediments at Slip 4. The screening levels incorporate a number of conservative assumptions, including the absence of contaminant dilution and ample time for contaminant concentrations in soil, sediment, and groundwater to achieve equilibrium. In addition, the screening levels do not address issues of contaminant mass flux from upland to sediments, nor do they address the area or volume of sediment that might be affected by upland contaminants. Because of these assumptions and uncertainties, these screening levels are most appropriately used for one-sided comparisons. If contaminant concentrations in upland soil or groundwater are below these screening levels, then it is unlikely that they will lead to exceedances of the SMS. However, upland concentrations that exceed these screening levels *may or may not* pose a threat to marine sediments; additional site-specific information must be considered in order to make such an assessment. While not currently considered COCs in sediment, these chemicals may warrant further investigation, depending on site-specific conditions, to evaluate the likelihood that they will lead to exceedances of the SMS criteria. Potential upland COCs are discussed as appropriate in Section 4.

2.3.3 COCs in RM 4.3-4.9 East Sediments

COCs were identified based on the results of sediment sampling conducted between 1997 and 2005, as described above. Chemicals that exceeded the SQS in at least one sediment sample near the BDC source control area (as shown on Figure 4) are considered COCs.

A total of 63 surface sediment samples have been analyzed. Of the 63 samples analyzed, five contained chemicals that exceed the SQS criteria (Table 2). No subsurface samples have been collected in this area.

The following chemicals are considered to be COCs in sediment for the BDC source control area[5]:

[5] Hexachlorobutadiene, 1,2,4-trichlorobenzene, and N-nitrosodiphenylamine were not detected in any samples, however laboratory detection limits for these analytes exceeded the SQS in all samples.

Chemicals Detected at Concentrations above the SQS/CSL	>SQS	>CSL
Metals		
Lead	●	●
PAHs		
Acenaphthene	●	
Benzo(g,h,i)perylene	●	
Dibenzo(a,h)anthracene	●	
Fluoranthene	●	
Indeno(1,2,3-cd)pyrene	●	
PCBs		
Total PCBs	●	

Exceedance factors, which are a measure of the degree to which maximum detected concentrations exceed the SQS/CSL values, are listed in Table 2.
Chemicals listed in this table are based on results of surface sediment sampling; no subsurface sediment samples have been collected in the BDC source control area.

Results for these chemicals are discussed in more detail below.

Metals

Lead is the only metal with a detected concentration above the SQS. Lead was detected at one location (DR254), just downstream of the Boeing pedestrian bridge, at a concentration of 620 mg/kg DW. This slightly exceeds the both the SQS (450 mg/kg DW) and the CSL (530 mg/kg DW).

PAHs

PAH concentrations exceeding the SQS were detected in two surface samples, R79 and R63. The concentration of acenaphthene (0.22 mg/kg DW, 20 mg/kg OC) exceeded the SQS in sample R79, located west of the Boeing pedestrian bridge near the upstream side of the BDC source control area (Figure 4).

At R63, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, fluoranthene, and indeno(1,2,3-cd)pyrene exceeded the SQS, with concentrations ranging from 19 mg/kg OC (dibenzo(a,h)anthracene) to 170 mg/kg OC (fluoranthene). None of these chemicals exceeded the CSL. R63 is located on the downstream end of the BDC source control area, near Outfall DC-13 and offshore of Building 9-12.

PCBs

PCB concentrations slightly exceeded the SQS in two sediment samples (R75 and B9a). These two samples, with concentrations from (0.26 to 0.27 mg/kg DW, 13 to 14 mg/kg OC) were collected near Outfall DC9, offshore of Building 9-96 (Figures 4 and 5).

2.3.4 Summary of Chemicals of Concern in Sediments

As described above, COCs were identified based on the results of sediment sampling conducted between 1997 and 2005. Chemicals that exceeded the SQS in at least one surface sediment sample offshore of the BDC source control area are considered COCs. No subsurface samples have been collected in this area.

In summary, the following chemicals are considered to be COCs in surface sediment near the BDC source control area:

- PCBs
- PAHs
- Lead

2.4 Potential Pathways to Sediment

Potential sources of sediment recontamination to RM 4.3-4.9 East include storm drains, adjacent properties, and contaminants transported along the LDW from upstream. No CSO outfalls are located within the BDC source control area. The Norfolk CSO/SD outfall is located upstream of the BDC source control area (Figure 2) and is discussed in detail in the EAA-7 Data Gaps Report and SCAP. There are no upland properties with stormwater drainage to the RM 4.3-4.9 area; other potential contaminant transport pathways to the LDW from upland properties are addressed as part of the EAA-7 and Slip 6 Data Gaps Reports and SCAPs.

Transport pathways that could contribute to the recontamination of sediments near the BDC source control area following remedial activities include direct discharges via outfalls, surface runoff (sheet flow) from the adjacent BDC property, bank erosion, groundwater discharges, air deposition, and spills directly to the LDW. These pathways are described below and are discussed in more specific detail in Sections 3 and 4.

2.4.1 Direct Discharges via Outfalls

Direct discharges may occur from public or private SD systems, CSOs, and emergency overflows (EOFs).

Some areas of the LDW are served by combined sewer systems, which carry both stormwater and municipal/industrial wastewater in a single pipe. These systems were generally constructed before about 1970 because it was less expensive to install a single pipe rather than separate storm and sanitary systems. Under normal rainfall conditions, wastewater and stormwater are conveyed through this combined sewer pipe to a wastewater treatment facility. During large storm events, however, the total volume of wastewater and stormwater can sometimes exceed the conveyance and treatment capacity of the combined sewer system. When this occurs, the combined sewer system is designed to overflow through relief points, called CSOs. The CSOs prevent the combined sewer system from backing up and creating flooding problems.

Untreated municipal/industrial wastewater and stormwater can potentially be discharged through CSOs to the LDW during these storm events. The City of Seattle owns and operates the local sanitary sewer collectors and trunk lines, while King County owns and operates the larger interceptor lines that transport flow from the local systems to the West Point Wastewater Treatment Plant (WWTP). The city’s CSO network has its own National Pollutant Discharge

Elimination System (NPDES) permit; the county's CSOs are administered under the NPDES permit established for the West Point WWTP.

An EOF is a discharge that can occur from either the combined or sanitary sewer systems that is not necessarily related to storm conditions and/or system capacity limitations. EOF discharges typically occur as a result of mechanical issues (e.g., pump station failures) or when transport lines are blocked; pump stations are operated by both the city and county. Pressure relief points are provided in the drainage network to discharge flow to an existing storm drain or CSO pipe under emergency conditions to prevent sewer backups. EOF events are not covered under the city's or county's existing CSO wastewater permits.

When preparing a Data Gaps Report for a source control area, all properties that potentially discharge to that source control area (whether through a CSO/EOF or a separated storm drain) are identified to the extent that the boundaries of the drainage basin are known. However, for areas where drainage basins overlap, a property review is performed only if the property has not already been included in a previously published Data Gaps Report. Exceptions include situations where contaminants may be transported to the current source control area via a transport pathway that was not applicable for the earlier evaluation.

As noted above, ten active private outfalls and one abandoned outfall are present within the RM 4.3-4.9 East source control area (Figure 2). Contaminants discharged via these outfalls could directly affect waterway sediments. There are no CSO or EOF outfalls within the RM 4.3-4.9 East source control area.[6]

2.4.2 Surface Runoff (Sheet Flow)

In areas lacking collection systems, spills or leaks on properties adjacent to the LDW could flow directly over impervious surfaces or through creeks and ditches to the waterway. Current operational practices at adjacent properties could potentially contribute to the movement of contaminants to the LDW via runoff. The BDC property has an extensive stormwater collection system, as shown in Figure 5, and surface runoff to the LDW from this property is not considered a significant transport pathway to sediments associated with the BDC source control area.

2.4.3 Spills to the LDW

Near-water and over-water activities have the potential to impact adjacent sediment from spills of material containing COCs. There are no docks or waterfront activities at the BDC property bordering the RM 4.3-4.9 source control area; therefore, spills directly to the LDW from this property are not considered a significant transport pathway to sediments associated with the BDC source control area.

2.4.4 Groundwater Discharges

Contaminants in soil resulting from spills and releases to adjacent properties may be transported to groundwater and subsequently be released to the LDW. Contaminated groundwater and flow

[6] The Norfolk CSO is located to the south near RM 5.0.

directions toward the LDW have been documented at the BDC; however, none of the sediment COCs listed in Section 2.3.4 above were identified as groundwater contaminants at the BDC (see Section 4.1.5 for more information). The southern portion of the RM 4.3-4.9 East shoreline was identified as an area with higher general seepage, as indicated by numerous rivulets flowing along the shore. Four seeps have been identified along the shoreline of the BDC source control area, as shown on Figure 2 (Windward 2004). None of these seeps has been sampled. Transport of contaminants to the LDW via groundwater discharge is considered a potential transport pathway to sediments associated with the BDC source control area.

2.4.5 Bank Erosion

The banks of the LDW shoreline are susceptible to erosion by wind and surface water, particularly in areas where banks are steep. Shoreline armoring and the presence of vegetation reduce the potential for bank erosion. Much of the bank along RM 4.3-4.9 East is riprapped with up to 12 vertical feet of rock. There is a narrow strip of vegetation along most of the shoreline in this area. Aerial photographs appear to show short (<100-foot) lengths of bulkhead in three locations. Contaminants in soils along the banks of the LDW, if present, could be released directly to sediments via erosion.

2.4.6 Atmospheric Deposition

Atmospheric deposition occurs when air pollutants enter the LDW directly or through stormwater. Air pollutants may be generated from point or non-point sources. Point sources include industrial facilities, and air pollutants may be generated from painting, sandblasting, loading/unloading of raw materials, and other activities, or through industrial smokestacks. Non-point sources include dispersed sources such as vehicle emissions, aircraft exhaust, and off-gassing from common materials such as plastics. Air pollutants may be transported over long distances by wind, and can be deposited to land and water surfaces by precipitation or particle deposition.

Contaminants originating from nearby properties and streets may be transported through the air and deposited at RM 4.3-4.9 East or in areas that drain to the LDW. Although chemical deposition from air directly to the LDW probably occurs, this mechanism is not likely to result in sediment concentrations above local background levels. The BDC facility has a Synthetic Minor Air Operating Permit issued by the Puget Sound Clean Air Agency (PSCAA). The permit limits annual air emissions by the following amounts: less than 99 tons of VOCs, less than 9.5 tons of any single Hazardous Air Pollutant (HAP), and less than 24 tons of any combination of HAPs. The air permits are assumed to protect sediments from the impact of air deposition via stormwater discharge to the river. However, the connection between atmospheric deposition and sediments for specific COCs needs to be studied before informed conclusions are possible.

Additional information on recent and ongoing atmospheric deposition studies in the LDW area is summarized in the LDW Source Control Status Report (Ecology 2007a and subsequent updates). Ecology will continue to monitor these efforts.

This page intentionally left blank.

3.0 Potential for Sediment Recontamination from Outfalls

3.1 Public Outfalls

No public outfalls are located within the BDC source control area. As noted previously, the Norfolk CSO/SD is described in the 2007 EAA-7 Data Gaps Report (E&E 2007) and SCAP (Ecology 2007b). Boeing discharge point DC1 drains into the municipal SD system, which discharges into the LDW via the Norfolk CSO/SD outfall (E&E 2007).

3.2 Private Outfalls

According to the 2010 BDC Stormwater Pollution Prevention Plan (SWPPP) (Boeing 2010a), there are 18 active outfalls on the BDC property that discharge directly to the LDW; 10 of these outfalls are located within the BDC source control area (Figure 2). Except where noted, the following descriptions are based on descriptions in the 2010 SWPPP.

The following outfalls discharge to the BDC source control area (listed from north to south):

LDW RI Outfall No.[1]	Boeing Outfall No.	Description[2]	Pipe Diameter/ Material	Outfall Discharge Volume[3]
2089	DC13	Drains the roof of Building 9-12 (cafeteria, now closed); the southern half of Building 9-08; a small portion of the south end of Building 9-77; paved areas around these buildings; and a greenbelt corridor next to the river. Runoff collected in this drain line system discharges via an oil/water separator.	24-inch concrete	Medium
2088	DC12	Drains a large narrow portion of the facility from the east to west boundaries of the property, including half of the roof areas of Buildings 9-53 and 9-55; all of the roof areas of Buildings 9-43, 9-48, 9-49, 9-51, 9-52, and 9-54; the paved areas around those buildings (parking, driving, storage, a gas station); and a planted pedestrian corridor, which follows the center length of this area. Runoff is collected into a centralized drain system and four oil/water separators before discharging to the LDW (Bet 2009).	36-inch concrete	Large
BDC-1	DC18	Drains a single line from a catch basin in the parking lot northwest of Building 9-99.	Unknown	Very Small
2087	DC11	Drains long and narrow portion running across the middle of the property from the east to west boundaries, including half of the roof areas of Buildings 9-99, 9-53, 9-42, and 9-55; extensive parking and driving areas; and the main driving entry to the property. Runoff is collected into a centralized drain line and discharges via an oil/water separator to the LDW.	36-inch	Large
2086	NA	Outfall is bricked shut, but discharge was observed during the outfall survey (Windward 2010).	48-inch riveted CMP	Low

LDW RI Outfall No.[1]	Boeing Outfall No.	Description[2]	Pipe Diameter/ Material	Outfall Discharge Volume[3]
2085	DC10	Drains half of the roofs of Building 9-98 and 9-99, plus paved areas (parking, driving, storage) around portions of those buildings. Runoff is collected into a centralized drain line and discharges via an oil/water separator to the LDW.	36-inch concrete	Medium
2090	DC9	Drains nearly one quarter of the BDC property, including half of the roof areas from Buildings 9-98, 9-101, and 9-120; all of the roof areas of Buildings 9-59, 9-60, 9-61, 9-62, 9-66, 9-67, 9-90, and 9-96; the paved areas (parking, driving, storage) around all of these buildings; and some small planted areas. Runoff is collected into an extensive SD system and discharges via an oil/water separator to the LDW.	36-inch concrete	Very large
BDC-2	DC8	Drains a portion of the paved area west of Building 9-120 into a series of catch basins; runoff is collected into a single drain line that discharges to the LDW.	Unknown	Small
BDC-3	DC7	Drains a portion of the paved area west of Building 9-120 into one catch basin; runoff is collected into a single drain line that discharges to the LDW.	Unknown	Very Small
BDC-4	DC6	Drains a portion of the paved area west of Building 9-120 into one catch basin; runoff is collected into a single drain line that discharges to the LDW.	Unknown	Very Small
2091	DC5	Drains the southwest corner of Building 9-101; all of Buildings 9-80, 9-85, and 9-102; and the paved areas (parking, driving, storage) around these buildings. Runoff is collected into a SD system and discharges via an oil/water separator to the LDW.	36-inch CMP	Small

1. Outfall number as listed in Windward 2010, Appendix H.
2. Sources: Ecology 2007b; Windward 2010; Boeing 2003; Bet 2009; Herrera 2004
3. Outfall discharge volumes are presented as listed in Boeing 2010a; no definitions are provided.

The Slip 6 Data Gaps Report (E&E 2008) indicated that stormwater from Building 9-04 at the MOF property appeared to discharge to Outfall DC9 (2090). However, the most recent BDC stormwater drainage map (Boeing 2009c) shows that stormwater drainage from the portion of the MOF property that includes Building 9-04, and the parking areas to the northwest, is discharged via Outfall DC15 to Slip 6 (Figure 5).

The BDC has 13 oil/water separators, including 12 baffle-type oil/water separators and one venturi-style sediment separator that also acts as an oil/water separator (Bet 2009); locations are shown in Figure 6. Nine of these oil/water separators are located within the BDC source control area, on storm drain lines that discharge to the LDW through outfalls DC13, DC12 (four oil/water separators), DC11, DC10, DC9, and DC5. Much of the stormwater from the BDC source control area passes through these oil/water separators prior to being discharged to the LDW. Small drainage areas, with small surface area and relatively low activity, are not serviced with oil/water separators and discharge directly from the BDC source control area to the LDW via outfalls DC18, DC8, DC7, and DC6.

Sampling of water and sludge/sediment from oil/water separators was conducted in 2002; results identified total PCBs at concentrations up to 4.4 µg/L in water and 30.9 mg/kg DW in sediment/sludge (PPC 2003). Additional information about storm drain system sampling is provided in Section 4.1.5.

3.3 Data Gaps

Outfall 2086 appears to be abandoned; however, discharge has been observed. The status of this outfall needs to be confirmed.

Based on the available data, stormwater may represent a potential source of PCBs to LDW sediments. While PCBs are present in the BDC SD system, PCB concentrations in LDW surface sediment samples collected near the BDC outfalls exceeded the SQS in only two of 63 surface sediment samples, both located near outfall DC9. No subsurface sediment samples have been collected in the BDC area.

Additional data on concentrations of PCBs in sediment near the outfalls as well as in stormwater and SD solids in the stormwater system at the BDC are needed to determine whether current discharges may adversely impact LDW sediments.

Additional data gaps associated with stormwater discharges are discussed in Section 4.1.6.

This page intentionally left blank.

4.0 Potential for Sediment Recontamination from Adjacent Properties

Property and facility-specific details regarding the parcels located within the BDC source control area are presented in this section. Tax parcels in the vicinity of the BDC source control area are shown in Figure 3, identified by the last four digits of the King County tax identification number.

Aerial photographs of the source control area for the years 1936, 1946, 1956, 1960, 1969, 1977, 1980, 1990, 1999, and 2004 are provided in Appendix B. A summary of the aerial photographs and changes observed over time is also included in Appendix B. An oblique aerial photograph of the source control area shoreline, taken in 2006, is provided in Figure 7.

Only one facility is located within the BDC source control area, as described below.

4.1 Boeing Developmental Center (BDC)

In this report, the term “BDC property” refers to any of The Boeing Company’s taxable land parcels in this area, including land parcels in the BDC (RM 4.3-4.9 East), Norfolk CSO/SD (RM 4.9 East), and Slip 6 (RM 3.9-4.3 East) source control areas. “BDC facility” is used to describe only the portions of The Boeing Company’s taxable land parcels that are located within the BDC source control area.

The BDC property consists of Parcels 1038, 1036, 1032, 0990, 0018, 0028, 0026, 0048, 9016, and 9183, as shown in Figure 3. Parcel 1038 and portions of Parcels 1032 and 1036 are within the stormwater drainage basin of the Slip 6 source control area, and were included in the Slip 6 Data Gaps Report and SCAP. Groundwater in these parcels also is believed to flow toward Slip 6 (E&E 2008).

Parcels 0028, 0026, 0048, 9016, and 9183, located in the southeastern portion of the BDC property, are within the stormwater drainage basin of the Norfolk CSO/SD (RM 4.9 East) source control area, and were included in the EAA-7 Data Gaps Report and SCAP. This southern portion of the BDC property includes the area within the stormwater drainage basin of the BDC South SD (Outfall DC1), as well as Outfalls DC2, DC3, DC16, DC4, and DC17 (see Section 2.1 for additional information).

Parcel 0992 is a Seattle City Light (SCL) right-of-way that runs through the BDC property (Figure 3). Information listed in the table below is for the entire BDC property, including areas within the BDC source control area, the Slip 6 (RM 3.9-4.3 East) source control area, and the Norfolk CSO/SD (RM 4.9 East) source control area.

Facility Summary: Boeing Developmental Center	
Tax Parcel No.	BDC source control area: 5624200990, 0003400018, 5624200992, portions of 5624201032 and 5624201036 Slip 6 source control area: 5624201038, portions of 5624201032 and 5624201036 Norfolk CSO/SD source control area: 0003400028,

Facility Summary: Boeing Developmental Center	
	0003400026, 0003400048, 0423049016, 0423049183
Address	9725 East Marginal Way S, Tukwila 9806 East Marginal Way S, Tukwila 9501 East Marginal Way S, Tukwila
Property Owner*	0018, 0028, 1032, 1036, 1038, 9183: The Boeing Company 0026, 0048, & 9016: East Marginal Way Associates 0990: Mellon Trust of Washington et al. 0992: Seattle City Light
Parcel Size*	0990: 14.21 acres 0018: 61.44 acres 0992: 2.8 acres 1032: 25.74 acres 1036: 3.25 acres 1038: 3.78 acres 0028: 2.25 acres 0026: 3.88 acres 0048: 1.38 acres 9106: 3.17 acres 9183: 0.79 acre
Facility/Site ID	2101 (Boeing A&M Developmental Center; Boeing BAS Development Ctr; Boeing Developmental Center; Developmental Center) 4581384 (Boeing Development Center Norfolk) Slip 6 source control area: 95718589 (Boeing Drum; 9725 East Marginal Way Gate J28; currently part of MOF)
SIC Code(s)	3721 – Aircraft
NAICS Code/Description	336411 – Aircraft Manufacturing
EPA ID No.	WAD093639946
NPDES Permit No.	SO3000146
KCIW Discharge Authorization No.	526-04
UST/LUST ID No.	UST: 10408 (Boeing Develop Center BLDG 9-52)
VCP Site No.	NW0324; NW1083

*Listed by last four digits of King County tax parcel number.

The BDC property is bordered to the north by Container Properties LLC (9229 East Marginal Way S, Parcel 0010); to the northeast by a parcel owned by the King County MOF (no listed address, Parcel 1034); to the east by the Museum of Flight (9494 East Marginal Way S, Parcel 9019); to the southeast by the Boeing MFC (10002 East Marginal Way S, Parcel 0021) and several small industrial parcels owned by Michigan Properties, 3301 South Norfolk LLC, Buty LP/Martin Burton, and 10230 East Marginal LLC; to the south by the Strick Lease Storage yard (no street address, Parcel 9002); and to the west by the LDW. Facility information and data gaps for the MFC were described in the EAA-7 Data Gaps Report (E&E 2007).

According to King County tax assessor records there are 39 buildings on the BDC property. There are none listed for Parcels 0026, 0028, 0048, 0992, 1036, 9016, and 9138. All of those parcels are parking lots, with the exception of 0992 and 9183, which are rights-of-way. Parcel 9016 is listed as vacant but aerial photographs show it is used for parking. King County tax assessor records indicated the following information about buildings on the other parcels:

Parcel	Bldg. No.	Year Built	Square Footage	Predominant Use
0018	9-42	1985	1,414	Office Building
	9-50	1957	47,874	Storage Warehouse
	9-59	1962	1,295	Office Building
	9-60	1961	3,458	Storage Warehouse
	9-61	1968	2,903	Office Building
	9-64	1970	2,020	Industrial Light Manufacturing
	9-65	1957	1,134	Industrial Engineering Building
	9-66	1975	2,220	Retail Store
	9-67	1985	3,812	Industrial Light Manufacturing
	9-69/9-70	1980	1,900	Storage Warehouse
	9-80	1957	4,704	Industrial Engineering Building
	9-85	1962	2,289	Industrial Engineering Building
	9-90	1961	143,575	Office Building
	9-94	1961	18,594	Cafeteria
	9-96	1961	217,537	Office Building
	9-98	1962	145,382	Office Building
	9-101	1957	1,112,432	Industrial Heavy Manufacturing
	9-102	1983	13,110	Industrial Engineering Building
	9-103	1985	4,736	Industrial Light Manufacturing
	9-110	1963	10,393	Office Building
	9-120	1957	177,470	Industrial Light Manufacturing
	9-130	1957	3,051	Office Building
	9-140	1957	17,110	Office Building
	17-62	1967	2,068	Storage Warehouse
0990	9-43	1961	1,425	Industrial Light Manufacturing
	9-48	1961	2,284	Storage Warehouse
	9-49	1962	4,840	Storage Warehouse
	9-52	1986	7,930	Storage Warehouse
	9-53	1987	140,045	Industrial Engineering
	9-54	1980	9,365	Storage Warehouse
	9-55	1987	1,344	Office Building
	9-57	1986	858	Storage Warehouse
	9-99	1969	70,235	Industrial Light Manufacturing
1032	9-08	1990	244,121	Office Building
	9-12	1991	9,022	Cafeteria
	9-35	1967	455	Storage Warehouse
	9-51	1986	76,744	Garage, Service Repair
	9-77	1986	70,964	Industrial Engineering Building

4.1.1 Physical Setting

The Boeing SWPPP for the BDC estimates that this facility is developed with 100 percent impervious surfaces, with very little natural vegetation or landscaping present (Boeing 2009a) (Figure 2). The facility sits on the Duwamish River floodplain on the inside of an old meander loop that was filled in 1918 with dredge spoils (SAIC 1994). A characterization of the soils at Building 9-50 indicated that fill is present to depths of approximately 6 to 10 feet below ground surface (bgs) (Landau 1993). Duwamish River alluvium below the fill consists of primarily fine to medium sand.

A characterization of conditions at Building 9-50 indicated that shallow groundwater exists under apparently unconfined conditions at seasonal depths of 12 to 14 feet bgs (Landau 1993). The 1994 Resource, Conservation, and Recovery Act (RCRA) Facility Assessment indicated a 50-foot thick aquifer that is primarily unconfined except where a local, 1- to 3-foot silty aquitard produces a semi-confined condition (SAIC 1994). Flow within the aquifer is primarily horizontal with little vertical mixing. The uppermost aquifer rests upon a 20-foot thick marine silt unit that acts as an aquitard, separating a confined aquifer within sandy silts and silty sands beneath it. The confined aquifer is tidally influenced. There are no known municipal or domestic water wells within at least ½ mile of the facility (Landau 1993).

A groundwater elevation contour map is provided in Figure 8.

4.1.2 Historical Operations

In an effort to more thoroughly understand and evaluate historical facility operations and development in the BDC source control area, SAIC reviewed historical aerial photographs from 1936 to 2002. These photographs represent conditions during roughly each decade. The aerial photographs and complete descriptions for the years 1936, 1946, 1956, 1960, 1969, 1977, 1980, 1990, 1999, and 2004 are provided in Appendix B.

The BDC source control area was farmland until 1918 when the U.S. Army Corps of Engineers channelized the LDW. The earliest known commercial operations at the property began in 1927. The BDC property has been used as a meat packing facility (in the 1930s); a horse riding and training track; railroad tracks under various owner/lease agreements; and Pankrantz Lumber Company, which operated on portions of the property from 1943 to 1950. Boeing lease/ ownership began on various parcels in the mid-1950s.

The Boeing Developmental Center began operations in 1959. The facility was home to some of Boeing's most important research and development programs, including the Bomarc missile, Minuteman Intercontinental Ballistic Missile, Supersonic Transport, YC-14 short takeoff/landing transport, YF-22 fighter prototype, and the Boeing Joint Strike Fighter candidate. It has also been home to military production and modification programs including significant portions of the B-2 stealth bomber and military variants of Boeing commercial jets. The remains of a nonoperational Minuteman missile silo are still located in one corner of the site (Boeing 2009d).

Since the mid-1980s, the BDC has been the primary research and development center for carbon fiber structures on programs such as the B-2, 777 empennage, F-22, 787, and various proprietary programs. The BDC programs are also responsible for the modification of advanced aircraft such as E-3A Airborne Warning and Control System, 737 Airborne Early Warning and Control, C-40 transport, and P-8A Poseidon maritime patrol platform, and is the home for Boeing production work on the F-22 fighter (Boeing 2009d).

Given the historical use of the BDC property and the LDW bed composition, which is subject to high sediment loading from upstream deposits, it is possible that previous releases to sediments from the BDC property have been buried due to sedimentation. Core sediment samples from offshore of the BDC would provide a better understanding of subsurface sediment chemistry in this area.

4.1.3 Current Operations

The BDC is primarily an aircraft and aerospace research and development complex. Operations include manufacturing of airplanes and missiles, which involves machining of metal aircraft hardware, electroplating, chemical milling, conversion coating, painting, parts cleaning, and assembly (Landau 2002). The BDC currently builds the wing and aft fuselage of the F-22 fighter.

The portion of the BDC property within the BDC source control area comprises approximately 86 acres of the 174-acre BDC property. Buildings include offices as well as those that house aerospace manufacturing and support operations such as fabrication, composite material assembly, painting, and other activities.

The facility has been issued a Wastewater Discharge Authorization No. 526-04 from the King County Industrial Waste Program to discharge wastewater generated from the vactor decant station operations, composite parts wash stall operations, photo processing, water jet cutting operations, and groundwater remediation activities. This authorization is effective November 17, 2005, through November 16, 2010 (E&E 2007).

Although the BDC has maintained an Individual Wastewater Discharge permit in the past, according to Ecology's online NPDES and State Waste Discharge Permit database[7], this facility currently operates under the Industrial Stormwater General Permit (SO3000146). A new Industrial Stormwater General Permit went into effect on January 1, 2010.

On Ecology's ISIS database, the BDC (Boeing Development Center Norfolk, Facility ID No. 4581384) is listed as having PCB concentrations in soil below the Model Toxics Cleanup Act (MTCA) cleanup level for PCBs (Ecology 2009b). The Boeing A&M Developmental Center, Facility Site ID No. 2101, is also listed as having confirmed groundwater and soil contamination and suspected surface water, air, and sediment contamination (Ecology 2009c). The contaminants are listed as base/neutral/acid organics, priority pollutant metals, petroleum products, and non-halogenated solvents. In addition to these contaminants, chlorinated solvents, including tetrachloroethene, cis-1,2-dichloroethene, and vinyl chloride, were identified as contaminants of concern in groundwater as part of the EPA RCRA investigations and corrective actions (Landau 2004b). RCRA corrective actions are discussed further below.

Ecology's online Regulated UST database lists eleven USTs for the BDC (identified as the Developmental Center). Six of these USTs are listed as having been removed, one as closed in place, one as exempt, and three as operational and containing diesel fuel or unleaded gasoline. The listed exempt tank, DCU-15, has a capacity of 300 gallons; it is part of an oil/water separator system and contains stormwater. Operational USTs listed on ISIS include: DCU-16 (1,000

[7] Online NPDES and State Waste Discharge Permit Database (accessed on 11/16/2009): http://www.ecy.wa.gov/programs/wq/permits/northwest_permits.html

gallons diesel); DCU-18 (550 gallons diesel); and DCU-19 (1,100 gallons unleaded gasoline). The BDC SWPPP lists a total of five operational USTs at the facility:

BDC Operational Underground Storage Tanks						
Tank ID Number	**Building**	**Location**	**Volume (gallons)**	**Content**	**Purpose**	**Containment**
DCU-16	9-101	South	1,000	Diesel	Emergency generator	Double-walled
DCU-18	9-52	North	550	Diesel	Vehicle Fuel	Double-walled
DCU-19	9-52	North	1,100	Unleaded gasoline	Vehicle Fuel	Double-walled
DCU-20 (Exempt)	9-72	West	20,000	Low sulfur diesel	Boiler	Double-walled
DCU-21 (Exempt)	9-72	West	20,000	Low sulfur diesel	Boiler	Double-walled

Information on aboveground tanks is provided in Appendix D.

The BDC is listed on Ecology's LUST database with release ID 1476. The status as of October 23, 2009, was "cleanup started" with a status date of June 1, 1995. Affected media was listed as soil and groundwater. Contaminated soil was removed when tanks DC-13 and DC-14 were replaced in 1990, and monitoring wells were installed. The two tank areas were later identified as AOC-01 and AOC-02. In November 2002, Ecology suspended groundwater monitoring requirements for AOC-01/02 based on data and information submitted by Boeing (Ecology 2002).

An inventory of air emission sources is provided in Appendix E.

Stormwater Discharges

According to the Boeing SWPPP (Boeing 2010a), stormwater from the BDC property is collected in catch basins and pipes and nearly all of it is discharged through those pipes to the LDW. There are 18 stormwater outfalls to the LDW from the BDC property; 10 of these are located within the BDC source control area. Approximate stormwater drainage areas for each of these 10 outfalls are shown in Figure 5. Six of the 10 stormwater discharge lines within the BDC source control area have in-line oil/water separators prior to discharge. There are a total of nine oil/water separators on these six lines, on storm drain lines that discharge to the LDW through outfalls DC13, DC12 (four oil/water separators), DC11, DC10, DC9, and DC5.[8] Much of the stormwater from the BDC property passes through these oil/water separators prior to being discharged to the LDW. Small drainage areas, with small surface area and relatively low activity,

[8] Additional oil/water separators are located on storm drain lines that discharge through outfalls DC14 and DC15 (within the RM 3.9-4.3 East [Slip 6] source control area) and outfalls DC2 and DC1 (within the RM 4.9 East ([Norfolk CSO/SD]) source control area.

are not serviced with oil/water separators and discharge directly from the BDC source control area to the LDW via outfalls DC18, DC8, DC7, and DC6.[9]

Under the Industrial Stormwater General Permit, Boeing is required to conduct monthly site inspections at outfalls that discharge from areas of industrial activity. Inspections include the following parameters: floating materials, visible oil sheen, discoloration, turbidity, and odor. The inspections also include observations to identify illicit discharges. Under the 2010 industrial stormwater general permit, Outfall DC9 was selected as the representative sampling point for the site. This outfall carries about one-fourth of the stormwater volume from the BDC property. Outfall monitoring will include quarterly samples collected at the outflow from the oil/water separator (DC9S) for the following parameters: total suspended solids (TSS), total zinc, total copper, oil sheen, turbidity, and pH (Boeing 2010a).

Potential stormwater pollution sources associated with the BDC source control area, as described in the 2010 SWPPP update, are listed below (Boeing 2010a).

Boeing Developmental Center Stormwater Pollution Risks		
Low Risk	**Minor Risk**	**Moderate Risk**
• Outdoor storage of metal chips and concrete slurry • Portable tanks	• Storage of material and equipment • Roof contamination • Accumulation and storage of hazardous wastes • Tank and drum storage of hazardous materials • Storage of chemical materials and products • Fueling stations • Vehicle maintenance and cleaning • Dust and particulate generation • Non-stormwater discharges • Decant station • Construction activities (depending on project specifics)	• Solid waste disposal practices • Material handling activities • Handling of hazardous waste • Transportation of material and wastes • Surplus tub-skid, test weight, huge-haul, and dumpster storage • Oil and gas tanks (7 above ground outdoors, 5 below ground) • Construction activities (depending on project specifics)

Materials Handling

According to the 2009 SWPPP (Boeing 2009a), numerous solvents, adhesives, coatings, and lubricants are used in various processes and are transported and stored on the property. Chemicals include acids, alkalis, paints, water treatment chemicals, gasoline, diesel fuel, propane, coolants, and lubricants. Materials used, treated, or stored in significant quantities include hydrofluoric acid, nitrogen, light catalytic petroleum, hydrotreated petroleum, and diesel fuel No. 2. Boeing maintains Hazardous Materials (HazMat) response teams at all major

[9] In addition, stormwater drainage through outfalls DC17, DC4, DC16, and DC3, located within the RM 4.9 (Norfolk CSO/SD) source control area, is not serviced by oil/water separators.

facilities, including the BDC. The Developmental Center/Military Flight Center Spill Prevention Control and Countermeasures Plan was updated in August 2009 (Boeing 2009b).

Boeing prepared and submitted Pollution Prevention Progress Reports to Ecology during the years 1992 through 2002. More recent reports, if they were prepared, were not available in the files reviewed for this assessment.

4.1.4 Regulatory History

The BDC is a regulated facility under RCRA. Investigative activities have been conducted to determine if soil contamination and a historical gasoline leak have impacted groundwater. Under its RCRA corrective action authority, EPA conducted a RCRA Facility Assessment in 1994, and identified 157 Solid Waste Management Units (SWMUs) and five Areas of Concern (AOCs) at the BDC (SAIC 1994). Subsequent investigation determined that most of these do not pose a threat to human health or the environment. RCRA corrective actions were taken at several units. Ecology has authority delegated from EPA to implement RCRA corrective action through the MTCA regulations (WAC 173-340) and oversees remedial activities conducted under the Ecology VCP. Additional information is provided in Section 4.1.5 below.

The files reviewed for this Data Gaps Report contained facility inspections by Ecology and/or EPA dating back to December 1981. Reports and letters in the files indicate that the following inspections and/or site visits were conducted at the BDC (responses from Boeing are indicated in the references column):

Boeing Developmental Center Inspections/Site Visits			
Date	**Type of Inspection**	**Corrective Actions Identified**	**Reference(s)**
December 1981	Dangerous Waste Compliance	None	Ecology 1981
February 1984	Dangerous Waste Compliance	None	Ecology 1984
October 1984	Dangerous Waste Compliance	Unknown – inspection report not found in files	SAIC 1985
April 1986	Stormwater/ Dangerous Waste	Required clearance with METRO for sanitary sewer discharges; oil/water separator maintenance; waste storage practices	Ecology 1986
March 1988	Dangerous Waste Compliance	Display appropriate signage, employee training, communication with local agencies, improve closure plans, properly label waste	EPA 1988
August 1989	Dangerous Waste Compliance	Proper certification of dangerous waste manifests; continuous inspection records	Ecology 1989, 1990a, 1990b; Boeing 1990
August 1991	Dangerous Waste Compliance	Revise employee training plan	Ecology 1991a, 1991b; Boeing 1991a, 1991b
July 1993	Dangerous Waste Compliance	Develop a written schedule for inspecting monitoring equipment, safety and emergency equipment, security devices, and operating and structural equipment	Ecology 1993a, 1994a, 1994b; Boeing 1994b

Boeing Developmental Center Inspections/Site Visits			
Date	**Type of Inspection**	**Corrective Actions Identified**	**Reference(s)**
November 1993	Dangerous Waste Compliance	None	Ecology 1993b
February 1995	NPDES permit application	None	Ecology 1995a
March 1995	Dangerous Waste Compliance	Properly label waste; properly maintain fire protection equipment; provide adequate secondary containment; correct errors in Waste Analysis Plan	Ecology 1995b. 1995c; Boeing 1995a, 1995b
October 1996	Water Compliance	Correct reporting of flows	Ecology 1996
December 1996	Dangerous Waste Compliance	General recordkeeping requirements; secondary containment requirements; update Waste Analysis Plan for the facility	Ecology 1997a; Boeing 1997
June 1998	Water Compliance / Stormwater	Remove obsolete dumpster	Ecology 1998a
April 2001	Dangerous Waste Compliance	None	Ecology 2001
March 2006	Stormwater Compliance	Quarterly monitoring required	Ecology 2006
March 2007	Underground Storage Tank	Provide documentation that overfill alarm for tank DCU-16 is activated when energized.	EPA 2007
June 2009	Dangerous Waste Compliance	Properly label waste, properly store waste	EPA 2009
March 2010	Underground Storage Tank	None	Ecology 2010

EPA filed a Notice of Violation (NOV) and Compliance Schedule for the BDC in August 1988 as a result of violations discovered during a dangerous waste compliance inspection in March 1988 (EPA 1988). Violations described in the NOV included missing warning signs in the Main Storage Area; inadequate training of personnel engaged in hazardous waste handling; failure to notify local police, fire departments, and emergency response teams regarding the layout of the facility and associated hazards; and observation of a hazardous waste container at the facility with no accumulation date. According to the NOV, Boeing first filed a Notification of Hazardous Waste Activity for the BDC in November 1980. Boeing responded to the NOV in September 1988 and addressed each issue identified by EPA (Boeing 1988). In particular, Boeing took issue with being cited for failing to notify local agencies as they have had long-standing working relationships with the local facilities (police, fire, etc.) and had provided back up support during local emergencies.

Boeing filed a revised Notification of Dangerous Waste Activities with Ecology in February 1994 (Boeing 1994a). The form indicated 15 different waste streams for the facility including paints, inks, barium, chromium, lead, mixed oils, petroleum distillates, waste photographic fixers and developers, and others.

Ecology conducted a water compliance inspection of the BDC in October 1996 for NPDES permit SO3000148-8 (Ecology 1996). (Note: a letter from Ecology in April 2003 indicates this permit was cancelled as of April 25, 2003 [Ecology 2003].) The inspector reviewed the facility's discharge monitoring reports and met with Boeing representatives to discuss operational questions and concerns relating to the upcoming permit renewal. The inspector's notes indicated that Boeing had been underestimating their average daily flow by averaging over calendar days rather than operational days. The inspector also noted that Boeing's request to increase flow volume to improve efficiency of the ground water remediation process would be granted if requested flow volumes were within the systems' operational capacity. No compliance concerns were noted.

In September 1997, Ecology accepted the final facility closure certification for the BDC (Weston 1997), indicating the facility could no longer store (> 90 days), treat, or dispose of dangerous wastes at the facility (Ecology 1997c). The BDC would maintain interim status as a dangerous waste storage facility until all requirements of RCRA corrective actions were completed to Ecology's satisfaction. Earlier in the year, Boeing was cited for not reporting flow as required in late December 1996 (Ecology 1997b).

Ecology conducted a water compliance inspection of the BDC in June 1998 for NPDES permit SO3000146B (Ecology 1998a). The inspector's notes indicated only one concern for stormwater at this facility: an old large dumpster near Building 9-64 that may have contained residual contamination and or/hydraulic leaks that could contaminate stormwater. The inspector recommended disposal of that large surplus dumpster.

A July 1998 letter from Ecology to EPA indicated that the BDC was operating as a small quantity generator and all dangerous waste storage units had been clean closed (Ecology 1998b). Ecology indicated they did not want to continue RCRA inspections of the BDC because of the facility's history and track record and because the agency had other high priority facilities needing inspections.

Ecology conducted an unannounced dangerous waste compliance inspection at the BDC in April 2001. The inspector noted that "dangerous waste compliance issues have been well addressed" and she did not observe any areas of non-compliance at the facility (Ecology 2001). Ecology files reviewed for this report included no other records of RCRA inspections until June 2009 (described below).

In November 2002, Ecology suspended groundwater monitoring requirements for AOC-01/02 based on data and information submitted by Boeing (Ecology 2002).

Ecology conducted a stormwater compliance inspection of the BDC in March 2006 for NPDES permit SO3000146D (Ecology 2006). The inspector's notes indicate the following information about this facility:

- hundreds of catch basins collect stormwater on the site and these are cleaned annually;
- equipment/vehicle washing occurs on the property and wash water is conveyed to the sanitary sewer;

- outside storage and parking areas are swept monthly;
- the stationary fueling area is not covered and stormwater is discharged to an oil/water separator before entering the stormwater system;
- some repair and maintenance of vehicles occurs outside; and
- oil/water separators are cleaned annually.

The inspector indicated that only one quarterly monitoring sample had been collected during 2005, in violation of conditions stipulated by the Industrial Stormwater General Permit. No stormwater inspection has been conducted at this facility since March 2006.

EPA inspected the three regulated USTs (DCU-16, DCU-18, and DCU-19) at the BDC in March 2007 (EPA 2007). The inspector noted that release detection systems appeared to be operating correctly; cathodic protection was performing adequately based on test results; and spill prevention and overfill protection was evident for all tanks. As a follow-up item, the inspector requested that Boeing provide documentation that the audible overfill alarm of DCU-16 would activate when energized. Boeing provided this documentation after the inspection (Boeing 2007).

An EPA RCRA inspection performed June 30, 2009, found two violations that resulted in a Notice of Violation being issued on July 27, 2009 (EPA 2009). According to the NOV, partially full boxes of universal waste lamps in Building 9-35 were left open instead of being closed per WAC 173-303-573 (9)(c)(ii). The second violation involved a 55-gallon drum of paint-related wastes in Building 9-140 that was unlabeled, in violation of WAC 173-303-630(3).

Ecology inspected the three regulated USTs (DCU-16, DCU-18, and DCU-19) at BDC in March 2010. All systems were in good order. There were no violations and no follow-up items (Ecology 2010).

A list of spills between mid-2004 and mid-2009 at the BDC property is provided in Appendix F.

4.1.5 Environmental Investigations and Cleanups

Several environmental investigations and cleanups have been conducted at the BDC, as described below.

RCRA Investigations and Cleanup Actions

As noted above under Regulatory History, RCRA corrective actions have been taken at several AOCs and SWMUs at the BDC facility. Locations of these units are shown on Figure 9. Investigations and cleanup actions for all of the defined AOCs and SWMUs were described in the RCRA Facility Assessment Report prepared in 1994 (SAIC 1994). A Boeing Corrective Action Report prepared in 2002 indicated that no further action was needed for SWMUs 15, 16, and 23–25 (Landau 2002). These SWMUs are not discussed further in this Data Gaps Report.

More recently, investigations and cleanup actions for AOC-05, and SWMUs 17 and 20 were described in the EAA-7 Data Gaps Report (RM 4.9 East, Norfolk CSO/SD) for data available through mid-2007 (E&E 2007). The most recent information available for these areas is summarized below. Appendix C provides excerpts (summary figures and selected data tables) from reports related to the RCRA cleanup actions at BDC for the period 2007 through 2010.

AOC-03/04

AOC-03/04 is the former location of USTs DC-03 and DC-04, which were used to store No. 5 fuel oil from 1957 until a leak was discovered in 1991 (Landau 2002). Both USTs were removed and replaced with DC-20 and DC-21 (see also Section 4.1.3 above). During excavation, approximately 250 cubic yards of petroleum hydrocarbon contaminated soil and 200 to 500 gallons of free phase hydrocarbon were removed. In 1992, a monitoring well (MW-21A) was installed to sample soil and groundwater for TPH. Since 1997, the well has been sampled biannually and analyzed for VOCs and diesel-range petroleum hydrocarbons. In June 2001, MW-21C was installed to monitor VOCs and diesel-range petroleum hydrocarbons. In December 2000, diesel-range petroleum hydrocarbon was detected at a concentration above groundwater screening levels in MW-21A. Concentrations of diesel-range petroleum hydrocarbons were non-detect in both wells in December 2001. At the time of the report in 2002, the two monitoring wells were to be sampled semi-annually until four consecutive groundwater samples were non-detect for diesel-range petroleum hydrocarbons. No additional documents information regarding the continued sampling of AOC-03/04 were available at the time this Data Gaps Report was prepared.

AOC-05

AOC-05 was the location of a former unleaded gasoline UST and includes Buildings 9-60 and 9-61 (Landau 2002). Pilot testing of anaerobic bioremediation was completed in 2007 (Landau 2007a, 2009a). Four months of monitoring showed that a one-time addition of ammonium nitrate resulted in the decrease of petroleum hydrocarbon concentrations by 50 percent and a decrease in benzene, toluene, ethylbenzene, and xylenes (BTEX) concentrations by as much as 98 percent. Contaminant concentrations rebounded, however, upon depletion of the injected nitrate as groundwater returned to equilibrium with sorbed mass and non-aqueous phase liquid mass remaining in the aquifer.

A second injection well was installed in February 2008 upgradient of the first well, and baseline groundwater monitoring was conducted (Landau 2009a). Baseline monitoring indicated that gasoline-range total petroleum hydrocarbons (TPH) and benzene concentrations were in excess of preliminary screening levels in the two injection wells (source zone wells) but not at downgradient wells. Ammonium nitrate solutions were injected into the two wells in February, June, and October 2008 to stimulate anaerobic degradation of gasoline contamination. Performance monitoring was conducted every other month beginning the first month after injection. Injected nitrate is depleted between injection events by the degradation process. Contaminant reductions of between 83 and 98 percent for gasoline-range TPH and benzene were achieved in the source area.

Monitoring performed after the October 2008 nitrate injection indicated a diminished rate of degradation, which was attributed to an inadequate availability of phosphorus (Landau 2009d). In June 2009, ammonium phosphate was injected with the ammonium nitrate solution. Data from the July 2009 monitoring event suggests that biotreatment of the contaminants and consumption of the nitrate by the microorganisms has improved. Maximum contaminant concentrations were 410 µg/L for benzene, 280 µg/L for toluene, 32 µg/L for ethylbenzene, 1,630 µg/L for total xylenes, and 19 mg/L for gasoline-range TPH. Nitrate concentrations, however, exceeded a set threshold of 10 mg/L in downgradient wells.

A rebound of TPH-G and BTEX, but a depletion of nitrate to less than the reporting limit (<0.1 mg/L) was observed during the September 2009 monitoring event. This was indicative of contaminant reduction through the addition of ammonium phosphate to the injection solution (Landau 2010a). Building upon the June 2009 injection, the October 2009 injection also included ammonium phosphate. During the November 2009 monitoring event, maximum contaminant concentrations were 340 µg/L for benzene, 140 µg/L for toluene, 27 µg/L for ethylbenzene, 3,000 µg/L for total xylenes, and 24 mg/L for gasoline-range TPH. Nitrate concentrations remained above a set threshold of 10 mg/L in downgradient wells. During a February 2010 monitoring event, all contaminant concentrations were below screening levels, suggesting that bioremediation is providing effective treatment of contaminants. However, nitrate continued to exceed action levels and monitoring will continue at additional downgradient wells until nitrate concentrations no longer exceed the threshold. An injection event is expected in 2010, but results from the February 2010 monitoring event suggested that an additional injection was not needed (Landau 2010a). Quarterly monitoring was to be performed in order to determine the need for additional injection events.

Additional information is provided in Appendix C1.

<u>SWMU-17</u>

SWMU-17 consists of a former 67-gallon sump and associated 4,000-gallon steel UST (DC-05), which were used to store waste hydraulic and engine oil. The sump and UST were closed and removed in early 1986. Although Ecology stated in 1988 that no further groundwater monitoring was required of the wells in this SWMU, five wells (BDC05-2A, BDC05-3, BDC05-4, BDC05-5, and BDC05-7) have been sampled from this area semi-annually. Samples were analyzed for VOCs, TPH, and metals (Landau 2002). A Pilot Test Work Plan to evaluate enhanced anaerobic bioremediation as a remedy for tetrachloroethene (PCE) and copper in the groundwater aquifer was prepared by Landau Associates in October 2008 (Landau 2008b) (Appendix C2). The plan included installation of an additional groundwater monitoring well at this SWMU, and performance monitoring.

After implementation of the work plan during October 2008 through February 2010, it was concluded that bioremediation stimulated by electro-donor injection resulted in reduction of PCE and trichloroethene (TCE) to below detection limits at the injection well and a 25 percent reduction at a downgradient monitoring well. Due to a smaller than anticipated radius of influence and very slow downgradient transport, relatively close spacing of injection points was recommended. Further analysis of chlorinated VOC groundwater impacts will be conducted to better define the area addressed by full scale treatment. According to Boeing's Pilot Test Report, no substantial effect of bioremediation of arsenic and copper was observed and no further action was to be performed due to natural background levels of these metals (Landau 2010b). Groundwater monitoring data for this SWMU can be found in the SWMU-17 Pilot Test Report (Landau 2010b).

SWMU-20

SWMU-20 is a former degreaser pit located in the northwest corner of Building 9-101. Trichloroethene (TCE) and PCE were released at this SWMU (Landau 2008a). Vinyl chloride, a TCE breakdown product, is also present in groundwater at this SWMU. A groundwater treatment system was operated at this SWMU between fall 1993 and December 2001. Monitoring was conducted for 2 years after the system was shut down to evaluate natural attenuation as a remedial alternative. When monitoring showed VOC concentrations had rebounded, Boeing proposed active remediation by enhanced *in situ* reductive dechlorination through electron donor amendment. The first injection treatment occurred in June 2004 and consisted of sodium lactate and a vegetable oil emulsion. Additional injections were performed in December 2004 and March 2005. The first two injections targeted the source zone while the third targeted elevated vinyl chloride concentrations at one of the downgradient wells.

A total of seven wells have been injected one or more times. The most recent monitoring information available (May 2008 data in Landau 2008a) indicate the electron donor injections successfully decreased TCE and breakdown products with no substantial rebound in the majority of wells in the treatment area. The observed rebound of vinyl chloride in some wells was attributed to slowing treatment of residual source material due to an inadequate amount of electron donor; additional substrate would be required to continue treatment. A fourth electron donor injection was performed in August 2008 (Landau 2009b, 2009c). Monitoring conducted in May 2009 indicated that treatment was enhanced at injection wells and other nearby wells. Maximum contaminant concentrations were 7.7 µg/L for PCE, 5.6 µg/L for TCE, 26 µg/L for cis-1,2-dichloroethene, and 6.3 µg/L for vinyl chloride (see also Appendix C3). Semiannual monitoring was scheduled to continue at this SWMU.

Storm Drain System Sampling and Cleanup

In 2002, Boeing collected samples of sludge/sediment and water from oil/water separators within the BDC source control area, and analyzed them for PCBs (PPC 2003). Results are listed below. It should be noted that there are some discrepancies between the sample locations listed in data tables in PPC (2003), the map of sampling locations in that same document, the list of oil/water separators and locations in the 2003 SWPPP (Boeing 2003), and the oil/water separators and locations in the 2010 SWPPP (Boeing 2010a). Figure 6 shows current oil/water separators and locations (Bet 2009).

Sample Location	Sample Location Notes	Date Sampled	Total PCBs in Water (µg/L)	Total PCBs in Sludge/Sediment (mg/kg)
DC5S		8/28/2002	1.0 E	
DC9S1	Not shown on sample location map in PPC 2003.	8/26/2002	<0.2 E	1.4 E
DC10S2	Sample location in PPC 2003 appears to be current location of DC9S.	8/26/2002 9/19/2002	4.4 E <1.4 E	
DC10S1		9/19/2002		30.9 5.5 (split sample)
DC10S(1)	Not clear if this is the same as DC10S1.	9/28/2002		9.7 D
DC10S(2)	Not clear if this is the same as DC10S2.	9/28/2002		7.4 D
DC10S(3)	Not shown on sample location map in	9/28/2002		5.9 D

Sample Location	Sample Location Notes	Date Sampled	Total PCBs in Water (µg/L)	Total PCBs in Sludge/Sediment (mg/kg)
	PPC 2003.			
DC10S(4)	Not shown on sample location map in PPC 2003.	9/28/2002		9.4 D
DC12S1/DC12S1		8/26/2002	<0.2 E	0.34 E
DC12S2		8/26/2002	0.4 E	
DC13S		9/19/2002	<1.4 E	
DC9-60 (D2116-S)	Waste characterization sample from Vactor Decant Bay, which drains to the sanitary sewer. Not shown on sample location map in PPC 2003.	9/30/2002		12.4 YD
DC9-60 (D2117-A)		9/30/2002	8.6 Y	
DC9-60 (D2118-A)		9/30/2002	<1.0	

E – Estimated; holding times were exceeded for these samples
D – Dilution
Y – Raised reporting limit due to matrix interference

The data quality review for the 2002 samples identified several issues, including holding time exceedances and sampling methodology problems. When collecting a sample from an oil/water separator, a solids sample was collected first, followed by a water sample. This resulted in increased turbidity in the water sample and likely affected the resulting water sample concentration. Despite the data quality issues, results indicate that PCBs are present in the BDC SD system. No information on more recent sampling of oil/water separators or other SD structures was available at the time this Data Gaps Report was prepared.

Storm Drain and Sediment Sampling Related to Outfall DC2

South SD Line: In the RM 4.9 East (Norfolk CSO/SD) source control area, the South SD line leading to Outfall DC2 has been extensively sampled for PCB contamination and has been cleaned on multiple occasions. A Vortechs 9000 sediment trap / oil/water separator vault was installed in this line in 2003 (Landau 2004a). Sampling and cleanup activities in this drainage system, through mid-2005, were described in the EAA-7 Data Gaps Report (E&E 2007). While the South SD line is not within the BDC source control area, outfall DC2 is located directly upstream of the BDC source control area. Recent information related to the South SD line is therefore summarized briefly below.

Boeing conducts annual maintenance and removal of accumulated solids from the sediment trap and oil/water separator in the South SD line. The May 2008 LDW Source Control Status Report (Ecology 2008a) described South SD line sampling conducted in 2006. SD solids collected in the line had PCB concentrations ranging from 5.9 to 38 mg/kg DW.

Solids from filter bags at Manhole 2 and 3 and from the sediment trap / oil/water separator were analyzed for PCBs in September 2007 (Calibre 2008). Total PCBs ranged from 1.67 to 2.28 mg/kg DW downstream from the separator (MH 2), 3.200 mg/kg DW upstream from the separator (MH 3), and 14.7 mg/kg DW in solids from the separator.

The August 2009 LDW Source Control Status Report (Ecology 2009a) described South SD line cleaning and sampling and sampling of the sediment trap / oil/water separator conducted in 2008. Aroclors 1248, 1254, and 1260 were detected in the Manhole 3 sample, with the higher concentrations predominantly 1248 and 1254. The total PCB concentration in this sample was 1.44 mg/kg DW (Calibre 2009). Total PCBs in the two solids samples collected from the sediment trap / oil/water separator were 13 and 32 mg/kg DW (Calibre 2009). Annual sampling has shown a steady decline in PCB concentrations since the initial cleanout in 2002, but concentrations remain elevated.

LDW Sediments: In September 2003, Boeing excavated approximately 60 cubic yards of PCB-contaminated sediment in front of Outfall DC2 and placed a permeable carbon fabric beneath a layer of clean sand. Results of sampling of the backfilled sand for recontamination with PCBs through 2005 were described in the EAA-7 Data Gaps Report (E&E 2007). The May 2008 LDW Source Control Status Report (Ecology 2008a) described sampling of the sediment conducted in 2006. Samples collected from the backfill material had PCB concentrations ranging from <0.02 to 0.28 mg/kg DW (approximately 16 mg/kg OC).

Three stations at the removal area were sampled in September 2007 (Calibre 2008). PCBs were not detected in two of the three locations. The total PCB concentrations at location S1 were 0.14 and 0.20 mg/kg DW in two splits of the same sample. Three stations at the removal area were sampled in February 2009; PCBs were not detected in any of the samples (Calibre 2009). Performance monitoring suggests that source control measures have been effective.

4.1.6 Potential for Sediment Recontamination

Historical operations at the BDC facility resulted in releases of petroleum hydrocarbons, VOCs, SVOCs, total PCBs, and metals to soil and groundwater beneath the property (Landau 2002). The potential for sediment contamination associated with the BDC source control area is summarized below by transport pathway.[10]

Stormwater Discharge

The BDC source control area contains 10 active outfalls and one abandoned outfall. The majority of the stormwater drainage area of the facility is serviced by oil/water separators prior to discharge to the LDW (Boeing 2009a). Samples of water and sludge/sediment in the oil/water separators in 2002 indicated PCBs at concentrations to up 4.4 µg/L in water and 30.9 mg/kg DW in solids (PPC 2003). However, as indicated in Section 3.2, when collecting samples from the oil/water separators, the solids sample was collected first, followed by the water sample. This resulted in increased turbidity in the water sample and likely increased the resulting water sample concentration. There is a potential for sediment contamination associated with the stormwater discharge pathway.

Surface Runoff/Spills

Due to the property's location adjacent to the LDW shoreline, contaminants (if any) suspended in surface runoff have the potential to reach the BDC source control area. However, the facility is almost entirely paved and contains an extensive network of catch basins that direct stormwater and spills to storm drains that discharge to the LDW. There are no commercial marine operations

[10] Data gaps associated with the RM 3.9-4.3 East (Slip 6) source control area and the RM 4.9 East (Norfolk CSO/SD; EAA-7) source control area are summarized in the Data Gaps Reports for these areas.

occurring at the BDC. Therefore, contamination from surface runoff or spills directly to the LDW at this location is considered unlikely.

Groundwater Discharge

Areas within the BDC source control area with known groundwater contamination include AOC-05, and SWMUs 17 and 20. Excavations were performed to remove contaminated soils at each of these locations (GeoEngineers 2000; Landau 2002). Groundwater contaminants include petroleum hydrocarbons and VOCs, including BTEX and chlorinated hydrocarbons; none of the sediment COCs listed in Section 2.3.4 have been identified as groundwater contaminants at the BDC. Bioremediation activities are ongoing at AOC-05 and SWMUs 17 and 20. Flow directions toward the LDW have been documented; however, based on monitoring data, Boeing has concluded that the extent of groundwater contamination in each of these areas is bounded by downgradient wells (Landau 2004b).

Four seeps were identified near the BDC source control area during a 2004 seep survey (Windward 2004); none of these seeps was sampled. Contaminants in stormwater and/or SD solids could be transported to groundwater through leaks and breaks in SD piping and structures. The potential for sediment recontamination associated with groundwater discharges is therefore unknown.

Groundwater samples at the MOF property (parcel 1034 in Figure 3) have detected petroleum hydrocarbons, and groundwater flow is to the west-southwest toward the LDW (Landau 2004c). MOF has filed a restrictive covenant with King County due to groundwater contamination at the southeast corner of the property. There is a low probability that petroleum-contaminated groundwater from the MOF area could impact the BDC source control area. Additional information is provided in the Data Gaps Report for Slip 6 (E&E 2008).

Bank Erosion

A portion of the BDC property is located along the embankment of the LDW. Contaminants in soils along the banks of the LDW, if present, could be released directly to sediments via erosion. No information is available regarding contaminants in bank soils. The potential for recontamination of LDW sediments through bank erosion is unknown; however, much of the river bank in this area is riprapped.

This page intentionally left blank.

5.0 Summary of Data Gaps

No subsurface sediment samples have been collected in the LDW near the BDC source control area. This lack of LDW subsurface sediment data is considered a data gap. In surface sediment samples, detection limits for three chemicals (hexachlorobutadiene, 1,2,4-trichlorobenzene, and N-nitrosodiphenylamine) were above the SQS. Additional sediment data are needed to adequately assess the potential for historical sediment contamination associated with the BDC source control area.

Additional data gaps are summarized below, listed by potential sediment recontamination pathway.

5.1 Stormwater Discharges

The BDC source control area contains 10 active outfalls and one abandoned outfall. PCBs have been detected in oil/water separator samples collected in 2002 at concentrations of potential concern. No other information on sampling conducted within the SD lines that discharge to these outfalls was found in the files reviewed during preparation of this Data Gaps Report.

The following information is needed to assess the potential for sediment contamination associated with the stormwater pathway:

- Sampling data for PCBs and other COCs in SD solids are needed, particularly for SD lines associated with Outfalls DC3, DC12, DC11, DC10, DC9, and DC5, which are listed as having medium to high flow. Given the data quality issues associated with the 2002 oil/water separator samples, additional sampling of these units may be warranted.
- Verification is needed that Outfall 2086 is in fact abandoned, and that no flow discharges to the LDW from this location. Dye testing may be appropriate to verify that stormwater drainage lines are consistent with those shown in Figure 5.
- The most recent stormwater compliance inspection in the files reviewed during preparation of this Data Gaps Report was conducted in March 2006. A current stormwater compliance inspection is needed to verify compliance with applicable regulations and BMPs to prevent the release of contaminants to the LDW.
- Additional assessment of BDC's air emissions and air permit is needed to evaluate the potential for deposition on impervious surfaces and transport to the storm drain system.

5.2 Groundwater Discharge

Continued monitoring of RCRA cleanup activities within this source control area will minimize the potential for contaminants present in groundwater to enter the LDW. Updated information regarding the status of groundwater monitoring at AOC-03/04 is needed.

Groundwater seeps to the LDW have been documented in this area; however, no samples have been collected. Contaminants in stormwater, if present, could be transported to groundwater through leaking or broken pipes. Information on contaminant concentrations in seeps is needed if contaminants are detected at concentrations of concern in the storm drain system.

5.3 Bank Erosion/Leaching

Additional information about soil conditions along the bank of the LDW is needed to determine whether or not soil erosion is a potential source of sediment recontamination.

6.0 Documents Cited

Bet. 2009. Email from James Bet, The Boeing Company, to Jennifer Wallin, Science Applications International Corporation. Re: oil/water separators at the BDC site. November 25, 2009.

Boeing. 1988. Letter from James Johnstone, Boeing, to Charles Findley, U.S. Environmental Protection Agency. Re: Notice of Violation, HW-112. September 27, 1988.

Boeing. 1990. Letter from, Boeing, to Laurence Ashley, Ecology. Re: Compliance Issues Noted in Letter. March 8, 1990.

Boeing. 1991a. Letter from A.E. Whitson, Boeing, to Dean Yasuda, Ecology. Re: information requested during the August 14, 1991 inspection of the Developmental Center. September 19, 1991.

Boeing. 1991b. Letter from Laurence Weinberg, Boeing, to Josh Chaitin, Ecology. Re: August 14, 1991 Dangerous Waste Inspection of Boeing Developmental Center – Compliance with Washington State Dangerous Waste Regulations (WAC 173-303). November 25, 1991.

Boeing. 1994a. Form: Notification of Dangerous Waste Activities. Signed February 11, 1994. Submitted to Ecology.

Boeing. 1994b. Letter from Arthur Whitson, Jr., Boeing, to Jeannie Summerhays, Ecology. Re: Dangerous Waste Compliance Inspection, Developmental Center WAD 093 639 946 – Letter Dated January 18, 1994. March 2, 1994.

Boeing. 1995a. Letter from Andro Wipplinger, Boeing, to David Hohmann, Ecology. Re: March 9, 1995 Dangerous Waste Compliance Inspection, Boeing Developmental Center Facility, WAD 009262171. May 2, 1995.

Boeing. 1995b. Letter from J.T. Johnstone, Boeing, to Julie Sellick, Ecology. Re: Operation of Developmental Center Dangerous Waste Accumulation Tank. July 27, 1995.

Boeing. 1997. Letter from Andro Wipplinger, Boeing, to David Hovik, Ecology. Re: Dangerous Waste Compliance Evaluation Inspection, Boeing Developmental Center, WAD 096 639 946. February 21, 1997.

Boeing. 2003. Storm Water Pollution Prevention Plan, Boeing Developmental Center, Washington Department of Ecology Permit # SO3-000146. Prepared by The Boeing Company. December 2003 Revision. Certified April 13, 2006.

Boeing. 2007. Letter from Stephen Ryan, Boeing, to Todd Bender, EPA. Re: Confirmation of the Overfill Alarm of UST DC-16 at the Boeing Developmental Center, Tukwila, WA. April 6, 2007

Boeing. 2009a. Storm Water Pollution Prevention Plan, Boeing Developmental Center, Washington Department of Ecology Permit # SO3-000146. Prepared by The Boeing Company. August 31, 2009.

Boeing. 2009b. Developmental Center/Military Flight Center Spill Prevention Control and Countermeasures Plan. Prepared by Boeing Puget Sound Integrated Defense Systems Environment, Safety and Health. August 31, 2009.

Boeing. 2009c. Facility drainage map. November 13, 2009. Provided by Mr. James Bet, Boeing Environment, Health and Safety.

Boeing. 2009d. "Historical Perspective: 50 years at the leading edge; Developmental Center keeps proving 'it *can* be done'." *Boeing Frontiers*. August 2009.

Boeing. 2010a. Storm Water Pollution Prevention Plan, Boeing Developmental Center, PSEHS-WC-07 Rev B, Washington Department of Ecology Permit # WAR-000146. Prepared by The Boeing Company. July 13, 2010

Boeing. 2010b. Review Comments: Draft Lower Duwamish Waterway RM 4.3 to 4.9 East (Boeing Developmental Center), Summary of Existing Information and Identification of Data Gaps. July 2010.

Booth and Herman. 1998. Duwamish Coalition: Duwamish basin groundwater pathways conceptual model report. City of Seattle Office of Economic Development and King County Office of Budget and Strategic Planning, Seattle, WA. As cited in Windward 2003.

Calibre. 2008. 2007 Annual Sampling Report – South Storm Drain System, Boeing Developmental Center. Prepared for the Boeing Company Shared Services Group. May 20, 2008.

Calibre. 2009. Summary of Storm Drain Line Cleanout Work and 2008 Annual Sampling Report South Storm Drain System Boeing Developmental Center. Prepared for The Boeing Company. April 2009.

E&E (Ecology & Environment, Inc.). 2007. Lower Duwamish Waterway Early Action Area 7 Final Summary of Existing Information and Identification of Data Gaps Report. September 2007. Prepared for Washington Department of Ecology.

E&E. 2008. Lower Duwamish Waterway RM 3.9-4.4 East (Slip 6), Summary of Existing Information and Identification of Data Gaps, Final Report. February 2008. Prepared for Washington Department of Ecology.

Ecology. 1981. Interim Status Standards Notification – Boeing Developmental Center. Inspection by Julie Sellick, Ecology. December 14, 1981.

Ecology. 1984. Dangerous Waste Compliance Checklist/Questionnaire – Boeing Developmental Center. February 24, 1984.

Ecology. 1986. Letter from Kyle Cook, Ecology, to Douglas Weeks, Boeing Military Airplane Company. Re: Inspection of Boeing's Developmental Center and Airborne Warning and Control System (AWACS) Facility, Seattle, Washington, King County. May 1, 1986.

Ecology. 1989. Memo from D. Hideo Fujita, Ecology, to Julie Sellick and Laurence Ashley, Ecology. Re: Dangerous Waste Inspection – 23 August, 1989, Boeing Advanced Systems Development Center.

Ecology. 1990a. Letter from Laurence Ashley, Ecology, to J.T. Johnstone, Boeing Advanced Systems. Re: Hazardous Waste Compliance Inspection conducted on August 23, 1989. March 1, 1990.

Ecology. 1990b. Letter or memo from Laurence Ashley, Ecology, to Richard Mattrass, unspecified affiliation. Re: RCRA Inspection report for Boeing Advanced Systems Development Center conducted August 23, 1989. June 8, 1990.

Ecology. 1991a. Solid and Hazardous Waste Program Inspection Report – Boeing Advanced Systems Development Center. Inspection August 14, 1991. September 6, 1991.

Ecology. 1991b. Letter from Josh Chaitin, Ecology, to Art Whitson, Boeing Defense and Space Group. Re: Compliance with Washington State Dangerous Waste Regulations (WAC 173-303). October 29, 1991.

Ecology. 1993a. Dangerous Waste Inspection Checklist – Boeing Developmental Center. Inspector Jeannie Summerhays. July 28, 1993.

Ecology. 1993b. Waste Reduction, Recycling, and Litter Control Program – Site/Visit Contact Report. November 2, 1993.

Ecology. 1994a. Hazardous Waste and Toxics Reduction Program Inspection Report – Developmental Center WAD093639946. Inspector Julie Sellick. January 13, 1994.

Ecology. 1994b. Letter from Jeannie Summerhays, Ecology, to Mary Jo Donelly, Boeing Defense and Space Group. Re: Dangerous Waste Compliance Inspection Developmental Center WAD093639946. January 18, 1994.

Ecology. 1995a. Department of Ecology Inspection Report – Permit Application Boeing Developmental Center. Inspector Pam Elardo. February 23, 1995.

Ecology. 1995b. Hazardous Waste Inspection Report – Boeing Developmental Center. March 9, 1995.

Ecology. 1995c. Letter from J. David Hohmann, Ecology, to David Dornbush, Boeing. Re: 3/09/95 Dangerous Waste Compliance Inspection Boeing Developmental Center Facility WAD 009262171. April 12, 1995.

Ecology. 1996. Water Compliance Inspection Report – Boeing Developmental Center. Inspection October 31, 1996. Inspector Pam Elardo. November 7, 1996.

Ecology. 1997a. Letter from Dean Yasuda, Ecology, to Andy Wipplinger, Boeing Defense and Space Group. Re: Dangerous Waste Compliance Evaluation Inspection at the Boeing Developmental Center (WAD 093639946). January 15, 1997.

Ecology. 1997b. Letter from Kenneth White, Ecology, to Denis Bourcier, Boeing Developmental Control. Re: Monthly Discharge Monitoring Report violations, October 1, 1996 through December 31, 1996. March 4, 1997.

Ecology. 1997c. Letter from Julie Sellick, Ecology, to Andro Wipplinger, Boeing Defense and Space Group. Re: Ecology's Acceptance of Certification for Final Facility Clean Closure of the Boeing Developmental Center. September 3, 1997.

Ecology. 1998a. Water Compliance Inspection Report – Stormwater – Boeing Developmental Center. Ron Devitt, Inspector. Inspection on June 29, 1998. Report prepared July 6, 1998.

Ecology. 1998b. Letter from Erin Guthrie, Ecology, to Jack Boller, USEPA/WOO. Re: TSD Inspections for Boeing Plant 2 and Boeing Developmental Center. July 9, 1998.

Ecology. 2001. Letter from Tiffany Yelton, Ecology, to Thomas Gallacher, The Boeing Company. Re: Dangerous Waste Compliance Inspection at Boeing A&M Developmental Center RCRA ID WAD093639946 on April 24, 2001. May 4, 2001.

Ecology. 2002. Letter from Byung Maeng, Ecology, to James Bet, The Boeing Company. Re: Completion of Groundwater Monitoring at AOC-01/02 Boeing Developmental Center (WAD 093 639 946). November 25, 2002.

Ecology. 2003. Letter from Ecology to Tom Gallacher, The Boeing Company. Re: Cancellation of NPDES Permit No. WA-003148-8 Boeing Developmental Center. April 25, 2003.

Ecology. 2004. Lower Duwamish Source Control Strategy. Publication No. 04-09-043. January 2004.

Ecology. 2006. Stormwater Compliance Inspection Report: Boeing Developmental Center. March 16, 2006.

Ecology. 2007a. Lower Duwamish Waterway Source Control Status Report, 2003 to June 2007. Publication No. 07-09-064. Prepared by Washington State Department of Ecology, Northwest Regional Office, Toxics Cleanup Program. July 2007.

Ecology. 2007b. Lower Duwamish Waterway Source Control Action Plan for Early Action Area 7. Produced by Washington State Department of Ecology, Northwest Regional Office, Toxics Cleanup Program and Ecology and Environment, Inc. Publication No. 07-09-003. September 2007.

Ecology. 2008a. Lower Duwamish Waterway Source Control Status Report, July 2007 to March 2008. Publication No. 08-09-063. Prepared by Washington State Department of Ecology, Northwest Regional Office, Toxics Cleanup Program. May 2008.

Ecology. 2008b. Lower Duwamish Waterway River Mile 3.9-4.3 East (Slip 6) Source Control Action Plan. Produced by Washington State Department of Ecology, Northwest Regional Office, Toxics Cleanup Program and Ecology and Environment, Inc. Publication No. 08-09-001. September 2008.

Ecology. 2008c. Lower Duwamish Waterway Source Control Status Report April 2008 through August 2008. Publication No. 08-09-086. Prepared by Washington State Department of Ecology, Northwest Regional Office, Toxics Cleanup Program. October 2008.

Ecology. 2009a. Lower Duwamish Waterway Source Control Status Report September 2008 through June 2009. Publication No. 09-09-183. Prepared by Washington State Department of Ecology, Northwest Regional Office, Toxics Cleanup Program. August 2009.

Ecology. 2009b. Integrated Site Information System: Cleanup Site Details Report for Boeing Development Center Norfolk Site ID 4581384. Created October 19, 2009.

Ecology. 2009c. Integrated Site Information System: Cleanup Site Details Report for Boeing A & M Developmental Center Site ID 2101. Created October 23, 2009.

Ecology. 2010. Underground Storage Tank Inspection – Boeing Developmental Center. March 31, 2010.

EPA (U.S. Environmental Protection Agency). 1988. Notice of Violation and Compliance Schedule, in the matter of the Environmental Protection Agency, Region 10 vs. Boeing Developmental Center. August 29, 1988.

EPA. 2002. Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites. OSWER Directive 9285.6-08. U.S. Environmental Protection Agency. February 12, 2002.

EPA. 2007. Underground Storage Tank Inspection - Boeing Developmental Center. March 29, 2007.

EPA. 2009. Letter from Edward Kawalski, EPA, to Stephen Ryan, Boeing A & M Developmental Center. Re: Notice of Violation, Boeing A & M Developmental Center, EPA ID Number: WAD 09363 9946. July 27, 2009.

EPA and Ecology. 2002. Lower Duwamish Waterway Site Memorandum of Understanding between the United States Environmental Protection Agency and the Washington State Department of Ecology. April 2002.

EPA and Ecology. 2004. Lower Duwamish Waterway Site Memorandum of Understanding between the United States Environmental Protection Agency and the Washington State Department of Ecology. April 2004.

GeoEngineers. 2000. Phase I Environmental Site Assessment, 9725 East Marginal Way South, Seattle, Washington. Prepared for Museum of Flight. May 22, 2000.

Herrera. 2004. Summary Report: Lower Duwamish Waterway Outfall Survey. Prepared for Seattle Public Utilities by Herrera Environmental Consultants, Inc., Seattle, WA. January 2004.

Landau (Landau Associates Inc.). 1993. Site Characterization Building 9-50 Underground Boiler Fuel tank Replacement Project, Boeing Developmental Center Facility, Tukwila, Washington. Prepared for The Boeing Company Defense and Space Group. February 26, 1993.

Landau. 2002. Summary report: Corrective Action Boeing Developmental Center. Prepared for the Boeing Company, Seattle, Washington by Landau Associates, Edmonds, WA. February 27, 2002.

Landau. 2004a. Construction Completion Report Stormwater Treatment Vault Installation, Boeing Developmental Center, Tukwila, Washington. Prepared for The Boeing Company. February 26, 2004.

Landau. 2004b. Evaluation Report SWMU-17, SWMU-20, and AOC-05, Boeing Developmental Center, Tukwila, Washington. Prepared for The Boeing Company. March 10, 2004.

Landau. 2004c. Report: 2004 Annual Groundwater Monitoring Gate J-28/Museum of Flight, Tukwila, Washington. Prepared for The Boeing Company, Seattle, Washington. July 23, 2004.

Landau. 2007a. Technical Memorandum: AOC-05 Pilot Test Results, Enhanced Anaerobic Biodegradation of Petroleum Hydrocarbons, Boeing Developmental Center, Tukwila, WA. From Clint Jacob and Benni Jonsson to Jim Bet, The Boeing Company. October 3, 2007.

Landau. 2007b. Work Plan: AOC-05 Remedial Action Plan, Enhanced Anaerobic Biodegradation of Gasoline-Range Petroleum Hydrocarbons, Boeing Developmental Center, Tukwila, Washington. Prepared for The Boeing Company by Landau Associates. November 16, 2007.

Landau. 2008a. Technical Memorandum: SWMU-20 Work Plan Addendum Fourth Electron Donor Injection, Boeing Developmental Center, Tukwila, WA. From Benni Jonsson and Clint Jacob to Jim Bet, The Boeing Company. July 30, 2008.

Landau. 2008b. Work Plan SWMU-17 Pilot Test, Boeing Developmental Center, Tukwila, Washington. Prepared for The Boeing Company. October 2, 2008.

Landau. 2009a. 2008 Annual Report AOC-05 Remedial Action, Enhanced Anaerobic Biodegradation of Gasoline-Range Petroleum Hydrocarbons, Boeing Developmental Center, Tukwila, Washington. Prepared for The Boeing Company. March 13, 2009.

Landau. 2009b. May 2009 Semiannual Groundwater Monitoring Results, Boeing Developmental Center, Tukwila, Washington. Letter to Byung Maeng, Ecology, from Clinton Jacob, Landau Associates. July 16, 2009.

Landau. 2009c. May 2009 Semiannual Groundwater Monitoring Results, Boeing Developmental Center, Tukwila, Washington. Prepared for The Boeing Company by Landau Associates. July 16, 2009.

Landau. 2009d. Technical Memorandum: Update on AOC-05 Full-Scale Bioremediation Results, Enhanced Anaerobic Biodegradation of Petroleum Hydrocarbons, Boeing Developmental Center, 9725 East Marginal Way South, Tukwila, WA. From Clint Jacob and David Buser to James Bet, The Boeing Company. September 17, 2009.

Landau. 2010a. 2009 Annual Report: AOC-05 Remedial Action Enhanced Anaerobic Biodegradation of Gasoline-Range Petroleum Hydrocarbons, Boeing Developmental Center, Tukwila, Washington. April 9, 2010.

Landau. 2010b. SWMU-17 Pilot Test Report, Boeing Developmental Center, Tukwila, Washington. May 14, 2010.

NOAA (National Oceanic and Atmospheric Administration). 1998. Duwamish Waterway Sediment Characterization Study Report. National Oceanic and Atmospheric Administration, Seattle, WA. As cited in Windward 2003.

PPC (Project Performance Corporation). 2003. Data Quality Review/Assessment: Sampling and Analysis for PCBs in Storm Water System Oil/Water Separators, Developmental Center. Prepared for The Boeing Company. January 17, 2003.

SAIC (Science Applications International Corporation). 1985. Potential Hazardous Waste Site Preliminary Assessment. Summary Memorandum – Boeing Developmental Center. March 12, 1985.

SAIC. 1994. RCRA Facility Assessment Report for Boeing Developmental Center, Tukwila, Washington EPA I.D. No. WAD 09363 9946 and Boeing Military Flight Center, Seattle Washington, EPA I.D. No. WAS 98847 5943. Prepared for U.S. Environmental Protection Agency. September 1994.

SAIC. 2006. Soil and Groundwater Screening Criteria, Source Control Action Plan, Slip 4, Lower Duwamish Waterway. Prepared for Washington State Department of Ecology by SAIC, Bothell, WA. August 2006.

Weston (Roy F. Weston, Inc.). 1997. Closure Certification Building 9-50, 9-60 and 9-69/70 Container Storage Areas. Boeing Developmental Center, Tukwila, Washington. Prepared for The Boeing Company. April 1997.

Weston. 1999. Site inspection report: Lower Duwamish River. RM 2.5-11.5. Volume 1 – Report and appendices. Prepared by Roy F. Weston, Inc. for U.S. Environmental Protection Agency Region 10, Seattle, WA.

Windward (Windward Environmental LLC). 2003. Phase 1 Remedial Investigation Report, Final. Prepared by Windward Environmental LLC for the Lower Duwamish Waterway Group. July 3, 2003.

Windward. 2004. Data Report: Survey and Sampling of Lower Duwamish Waterway Seeps, Final. Prepared by Windward Environmental LLC for the Lower Duwamish Waterway Group. November 18, 2004.

Windward. 2005a. Data Report: Round 1 Surface Sediment Sampling for Chemical Analyses and Toxicity Testing. Final. Prepared by Windward Environmental LLC for the Lower Duwamish Waterway Group. October 21, 2005.

Windward. 2005b. Data Report: Round 2 Surface Sediment Sampling for Chemical Analyses and Toxicity Testing. Final. Prepared by Windward Environmental LLC for the Lower Duwamish Waterway Group. December 9, 2005.

Windward. 2006. Technical Memorandum: Criteria for Defining the Baseline Surface Sediment Dataset for Use in the Lower Duwamish Waterway Phase 2 RI/FS. Final. Prepared by Windward Environmental LLC for the Lower Duwamish Waterway Group. April 5, 2006.

Windward. 2007a. Data Report: Subsurface Sediment Sampling for Chemical Analyses. Final. Prepared by Windward Environmental LLC and RETEC for the Lower Duwamish Waterway Group. January 29, 2007.

Windward. 2007b. Data Report: Round 3 Surface Sediment Sampling for Chemical Analyses. Final. Prepared by Windward Environmental LLC for the Lower Duwamish Waterway Group. March 12, 2007.

Windward. 2008. Lower Duwamish Waterway Remedial Investigation Report. Draft Final. Prepared by Windward Environmental for the Lower Duwamish Waterway Group. October 30, 2008.

Windward. 2010. Phase 2 Remedial Investigation Report. Prepared by Windward Environmental LLC for the Lower Duwamish Waterway Group. July 9, 2010.