Lower Duwamish Waterway Slip 4 Early Action Area

LONG-TERM MONITORING DATA REPORT: YEAR 4 (2016)

FINAL

Prepared for

City of Seattle

For submittal to

US Environmental Protection Agency

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Seattle, WA 98101

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Acronyms

AOC	Administrative Order on Consent
ASAOC	Administrative Settlement Agreement and Order on Consent
Boeing	The Boeing Company
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
City	City of Seattle
DeNovo	DeNovo Seattle LLC
DSOA	Duwamish Sediment Other Area
EAA	Early Action Area
Ecology	Washington State Department of Ecology
EE/CA	engineering evaluation and cost analysis
EOF	emergency overflow
EPA	US Environmental Protection Agency
ESRI	Environmental Systems Research Institute
GPS	global positioning system
GTSP	Georgetown Steam Plant
ID	identification
KCIA	King County International Airport
LDW	Lower Duwamish Waterway
LTMRP	Long-term Monitoring and Reporting Plan
LTST	long-term stormwater treatment
MLLW	mean lower low water
MTCA	Model Toxics Control Act
NAD83/91	North American Datum of 1983/1991
NBF	North Boeing Field
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
PAH	polycyclic aromatic hydrocarbon

PARIS	permitting and reporting information system
PCB	polychlorinated biphenyl
QAPP	quality assurance project plan
RACR	removal action completion report
RAL	remedial action level
RCRA	Resource Conservation and Recovery Act
RI/FS	remedial investigation and feasibility study
RNA	Regulated Navigation Area
SCO	sediment cleanup objective
SMS	Washington State Sediment Management Standards
SPU	Seattle Public Utilities
SQS	Sediment Quality Standards
SVOC	semi-volatile organic compound
TEQ	toxic equivalent
TOC	total organic carbon
UAV	unmanned aerial vehicle
Waste Management	Waste Management National Services
Windward	Windward Environmental LLC

1 Introduction

This report presents the results of the Year 4 (2016) long-term monitoring of the Slip 4 Early Action Area (EAA) cleanup in the Lower Duwamish Waterway (LDW) Superfund site in Seattle, Washington (Figure 1-1). Year 4 monitoring was conducted by Windward Environmental LLC (Windward) in accordance with the long-term monitoring and reporting plan (LTMRP) (Integral 2013a).

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Figure 1-1. Location of the Slip 4 Early Action Area in Seattle, WA

Prepared by craigh, 9/19/2016; W:\Projects\City of Seattle Slip 4\Data\GIS\Maps and Analyses\Year 4 Data Report\Fig 1-1 6462 Slip 4 vicinity.mxd

1.1 BACKGROUND

On February 2, 2012, the City of Seattle (City) completed a non-time-critical removal action in Slip 4 to address sediment contaminated with polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), metals, and other organic compounds (Integral 2012). Details of the construction activities are summarized in the removal action completion report (RACR) (Integral 2012). The primary construction activities included:

- Dredging and excavation of approximately 10,256 cubic yards of contaminated bottom sediment and bank soil
- Transloading and disposal of 17,334 tons of soil, sediment, and debris in a Subtitle D landfill, including approximately 130 tons of creosote-treated timbers and piles
- Demolition of 20,019 ft^2 of concrete pier structure
- Recycling of 3,278 tons of concrete and 79 tons of steel
- Construction of stable slopes, sediment caps, and slope caps over 3.43 ac using 53,006 tons of clean material
- Construction of engineered soil covers and expanded habitat in former upland areas

The property adjacent to Slip 4 is currently owned by The Boeing Company (Boeing), First South Properties, and De Novo Seattle LLC (De Novo). The First South Properties property is being leased by Cedar Grove for the distribution of compost products and yard waste recycling. The De Novo property was formerly owned by Crowley Marine Services (1987–2014) and is currently leased by Waste Management. Waste Management is operating a soil/sediment transloading facility for the transfer of sacks of contaminated soil and sediment from barges to railcars (Figure 1-2).

There are three active public outfalls to Slip 4: the I-5 storm drain, the Georgetown storm drain, and the King County International Airport (KCIA) storm drain No. 3/PS44 emergency overflow (EOF) (Figure 1-2). In addition, there are private storm drains associated with the adjacent properties.

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N

0 25 50 Yards

0 20 40 Meters

Figure 1-2. Slip 4 properties

Prepared by craigh, 12/23/2016; W:\Projects\City of Seattle Slip 4\Data\GIS\Maps and Analyses\Year 4 Data Report\Fig 1-2 6555 Slip 4 properties.mxd

Photo source: USGS, High Resolution Orthoimagery:2898306_RGB23260025, 3 in resolution, 0.31 ft accuracy. Photo date April 2012.

Prior to the construction activities, source control actions were completed based on the results of the Slip 4 engineering evaluation and cost analysis (EE/CA) (Integral 2006). Actions taken to reduce the potential for recontamination of Slip 4 by stormwater discharge included:

- Replacement of the Georgetown Steam Plant (GTSP) flume with a 12-in.-diameter closed pipe in 2009 (the majority of stormwater from this area is now managed through on-site infiltration (Integral 2011))
- An interim action (completed in 2011), which included the excavation of contaminated soils from the North Boeing Field (NBF) and GTSP properties (Integral 2011)
- Installation of a long-term stormwater treatment (LTST) system by Boeing in 2011

Additional source control activities since the 2012 cleanup have also been conducted. These activities included (Integral 2015):

- Initiation of a remedial investigation/feasibility study (RI/FS) at the NBF/GTSP Model Toxics Control Act (MTCA) site
- Dredging in Slip 4, outside of this EAA, by Boeing in association with the Boeing Plant 2 Duwamish Sediment Other Area (DSOA) corrective measure
- Initiation of Phase 2 of an RI/FS at the DeNovo property under MTCA
- Inspections and sampling at the DeNovo property and First South Properties property in association with the National Pollutant Discharge Elimination System (NPDES)

Long-term monitoring is being performed according to the schedule outlined in Table 1-1[1]). Year 4 long-term monitoring activities conducted in 2016 (and summarized in this report) include a storm flow monitoring review (i.e., whether 100-year storm events occurred during the Year 4 monitoring period [July 1, 2015, through July 31, 2016]), a visual inspection, an institutional control update, and a review of construction activities and investigations performed by other parties.

Sediment and soil samples were not collected for chemical analysis in Year 4 (2016), but will be collected in future years as outlined in Table 1-1. In future data reports, those results will be compared with chemistry data from previous monitoring years, including the baseline sampling conducted in 2012; trends will be assessed. Overall, the intent of the monitoring program is to verify that the remedy remains protective of human health and the environment by addressing the following LTMRP questions (Integral 2013a):

[1] Previously presented as Table 2-2 in the LTMRP (Integral 2013a).

- Are contaminant concentrations in Slip 4 EAA surface sediments (0 to 10 cm) below applicable sediment quality standards (SQS)?
- Is the physical integrity of the cap in the Slip 4 EAA being maintained such that the sediment cap continues to isolate contaminants in underlying sediments from marine biota?
- Do the institutional controls associated with the Slip 4 EAA remedy remain in place and continue to work effectively?
- Are physical changes occurring related to sediment erosion and sediment deposition in the Slip 4 EAA?

Table 1-1. Long-term monitoring schedule

Monitoring Activities	Year to be Performed									
	1	2	3	4	5	6	7	8	9	10
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022[a]
Visual inspections[b]	X	X	X	X	X		X			X
Institutional control update	X	X	X	X	X		X			X
Review of physical construction/investigations by other parties	X	X	X	X	X		X			X
Review of storm flow monitoring data for 100-year events	X	X	X	X	X		X			X
Hydrographic surveys[c,d]					X					X
Topographic surveys[e]										
Sediment sampling[d]										
Composite slope cap samples (2)[f]	X		X		X		X			X
Discrete waterway cap samples (6)[f]	X		X		X		X			X
Discrete boundary area documentation samples (2)[g]	X									

[a] Subsequent monitoring after Year 10 will be determined upon consultation with EPA.

[b] Additional visual inspections will be performed after any significant seismic events (peak horizontal ground acceleration greater than 0.10 g).

[c] Multi-beam echo sounding at intervals not exceeding 20 ft, utilizing similar equipment and methods used for the removal action post-construction survey.

[d] Frequency may increase if warranted based on visual inspection.

[e] As needed based on visual inspection reports of significant physical disturbances observed (e.g., bank slope deformation) or after significant seismic events.

[f] 0–10-cm horizon. To be analyzed for all target analytes listed in Table A-1 of the QAPP (Integral 2013b).

[g] 0–10-cm horizon. To be analyzed for PCB Aroclors, TOC, and total solids.

EPA – US Environmental Protection Agency

PCB – polychlorinated biphenyl

QAPP – quality assurance project plan

TOC – total organic carbon

1.2 REPORT ORGANIZATION

The remainder of this report is organized as follows:

- Section 2. Year 4 Monitoring Components
- Section 3. Data Management
- Section 4. Results
- Section 5. Conclusions and Recommendations
- Section 6. References

Field notes and data, photographs, log books, and backup data are presented in the following appendices:

- Appendix A. Rain Gauge and Tide Data
- Appendix B. Visual Inspection Field Forms
- Appendix C. Visual Inspection Photographs
  - Appendix C1. Year 4 (2016) Photographs
  - Appendix C2. Comparison Photographs
- Appendix D. Copy of Logbook
- Appendix E. Other Investigations—Boeing
  - Appendix E1. LTST
  - Appendix E2. Plant 2 DSOA
- Appendix F. Other Investigations—DeNovo Property RI/FS
- Appendix G. Other Investigations—City of Seattle Source Control

2 Year 4 Monitoring Components

Year 4 (2016) long-term monitoring activities included a storm flow monitoring review, a visual inspection of cap conditions, an update of institutional controls, and a review of construction activities and investigations performed by other parties and potentially impacting the Slip 4 EAA. A summary of these activities is presented in this section.

2.1 STORM FLOW MONITORING REVIEW

The LTMRP requires an evaluation of rainfall to estimate whether stormwater flows have the potential to erode the Slip 4 EAA cap (Integral 2013a). For the portion of the LDW that includes Slip 4, a 100-year storm event would correspond to 3.85 in. or more of rainfall within a 24-hr period, as measured by the Seattle Public Utilities (SPU) rain gauge (Station 45-S016, Metro King County, East Marginal Way).

Based on rain gauge data for Station 45-S016 for the period of July 3, 2015–July 5, 2016, obtained from SPU (2016), no 100-year storm events occurred within the Year 4 (2016) monitoring period. The maximum daily total rainfall was 1.62 in. (recorded on December 8, 2015). Consequently, no further evaluation of potential stormwater-induced erosion to the cap was necessary. Rain gauge measurements and predicted tide data from July 2015 through July 2016 (NOAA 2015, 2016b) are provided in Appendix A.

2.2 VISUAL INSPECTION

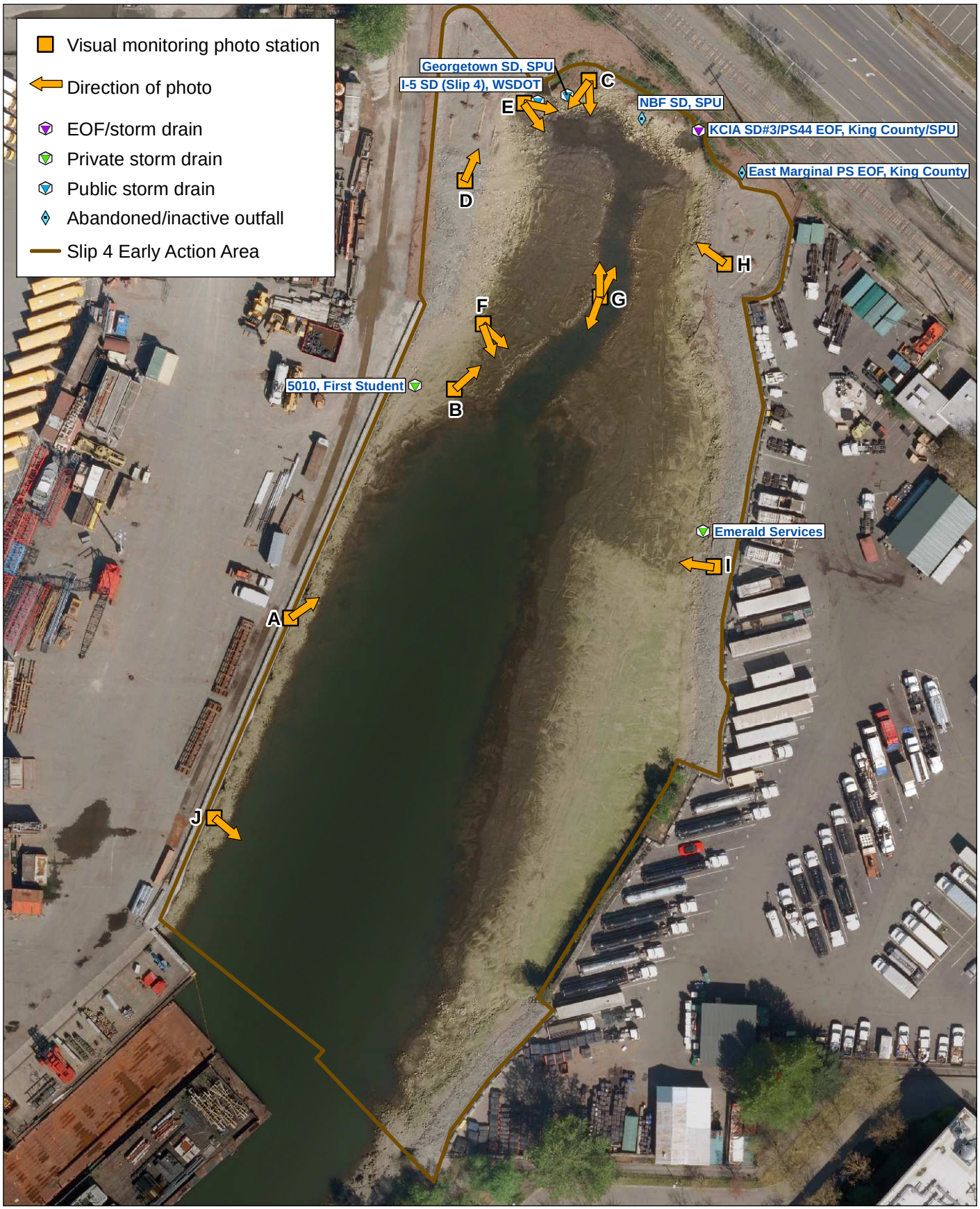
Slip 4 was visually inspected on July 5, 2016. This inspection documented the general condition of the cap, with a focus on any obvious changes in bathymetry/topography resulting from erosion or sedimentation processes, any signs of visible breaches of cap integrity, and any changes to the condition of constructed habitat features (e.g., integrity of anchored woody debris).

2.2.1 Site inspection

The visual inspection for the Year 4 (2016) monitoring was conducted in accordance with the LTMRP and quality assurance project plan (QAPP) (Integral 2013a, b). As part of this inspection, photographs were taken of the Slip 4 EAA sediments exposed during the extreme low tide. The tide level during the inspection ranged from –2.6 to 1.7 ft mean lower low water (MLLW), based on the predicted tide curve for the 8th Avenue South tide station (9447029). Photographs were taken, using a 16-megapixel digital camera (Olympus Stylus TG-860), from locations consistent with those used to document post-capping conditions prior to long-term monitoring surveys. The locations of the photo stations are presented in Figure 2-1; photo station coordinates, azimuths, photograph numbers, and target areas are included in Table 2-1. All

photographs taken during the Year 4 (2016) visual monitoring survey are included in Appendix C1.

During prior years' surveys, photo station locations were marked using brightly painted rebar stakes. All such stakes were still upright during the Year 4 (2016) inspection and were repainted by field personnel. Visual inspection forms and copies of the field logbook (Appendices B and D, respectively) were used to record observations of conditions in the areas represented by the photographs (Appendix C1). Figure 2-2 presents the nomenclature of the cap areas surveyed; a summary of the visual inspection observations is provided in Table 2-2.



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0 20 40 Yards

0 20 40 Meters

Figure 2-1. Locations of photo stations in Slip 4 Early Action Area and orientation of photos

Photo source: USGS, High Resolution Orthoimagery:2898306_RGB23260025, 3 in resolution, 0.31 ft accuracy. Photo date April 2012.

Prepared by craigh, 9/19/2016; W:\Projects\City of Seattle Slip 4\Data\GIS\Maps and Analyses\Year 4 Data Report\Fig 2-1 6464 Visual monitoring photo stations.mxd

Windward environmental LLC

N

0 50 100 Feet

0 10 20 Meters

Figure 2-2. Cap survey observation areas

Photo source: USGS, High Resolution Orthoimagery:2898306_RGB23260025, 3 in resolution, 0.31 ft accuracy. Photo date April 2012.

Prepared by craigh, 9/20/2016. W:\Projects\City of Seattle Slip 4\Data\GIS\Maps_and_Analyses\Year 4 Data Report\Fig 2-2 6464 Visual monitoring survey obs areas.mxd

Table 2-1. Photo log for Year 4 visual inspection

Photo Station ID	Target Coordinates				Marker Condition	Target Photo Orientation (T=True North, M=Magnetic North)	Actual Photo Orientation (Magnetic North)[b]	Photo ID	Photo Number[c]	Photo Time	Photo Target Area Description	Notes
	Latitude	Longitude	Northing[a]	Easting[a]								
A	47.536176[d]	-122.319524[d]	199125[d]	1273323[d]	good; needs paint	55° T; 39° M	39° (see note)	A1	100-0025	11:48	east-central sediment cap	repainted marker; compass reading unreliable (due to proximity of metal bulkhead)
B	47.536635	-122.319241	199292	1273396	good; needs paint	48° T; 32° M	32°	B1	100-0014	11:09	north sediment cap	repainted marker
C	47.537207	-122.318901	199499	1273484	good; needs paint	178° T; 162° M	162°	C1	100-006	10:38	northwest slope cap, south sediment cap	repainted marker
					good; needs paint	217° T; 201° M	201°	C2	100-007	10:40	northwest slope cap	repainted marker
D	47.537020	-122.319224	199432	1273403	good; needs paint	24° T; 8° M	8°	D1	100-0011	10:56	northwest beach/anchored logs	repainted marker
E	47.537169	-122.319075	199486	1273441	good, dirty; needs paint	102° T; 86° M	86°	E1	100-0008	10:47	north slope cap, outfalls	repainted marker
					good, dirty; needs paint	144° T; 128° M	128°	E2	100-0010	10:49	northeast slope cap, north rip rap slough	repainted marker
F	47.536768	-122.319172	199338	1273418	good; needs paint	133° T; 117° M	117°	F1	100-0012	11:02	east slope cap, east sediment cap, central rip rap slough	repainted marker
					good; needs paint	160° T; 144° M	144°	F2	100-0013	11:03	southeast slope and sediment cap	repainted marker
G	47.536813	-122.318864	199355	1273491	good; needs paint	200° T; 184° M	184°	G1	100-0015	11:17	south rip rap slough	repainted marker
					good; needs paint	27° T; 11° M	11°	G2	100-0016	11:18	north rip rap slough, sediment cap, north slope cap	repainted marker
					good; needs paint	0-360°	0–360°	G3	100-0017 to 100-0022[e]	11:19 to 11:20	entire Slip 4 EAA	repainted marker
H	47.536879	-122.318546	199378	1273570	good; needs paint	306° T; 290° M	290°	H1	100-0003	10:20	northwest slope cap, beach cap, sediment cap	repainted marker
I	47.536335	-122.318543	199177	1273570	good; needs paint	278° T; 262° M	262°	I1	100-0002	10:03	west sediment cap	repainted marker
J	47.535834[d]	-122.319738[d]	199002[d]	1273268[d]	good; needs paint	130° T; 114° M	114° M (see note)	J1	100-0024	11:41	southeast slope cap	repainted marker; compass reading unreliable (due to proximity of metal bulkhead)

[a] Washington State plane coordinate system, north zone (NAD83/91), US feet.
[b] Actual azimuth values are approximate, based on compass readings (referencing magnetic north) in the field. Magnetic north declination from true north for Seattle in July 2016 was 16° (NOAA 2016a).
[c] Photograph numbers were provided by the camera in the field and differ from the ID numbers generated after downloading.
[d] These target coordinates were re-located after Year 1 (2013) monitoring; the new target coordinates are approximate, as they are based on GPS satellite readings that experienced interference due to the proximity of metal bulkhead.
[e] The six individual photographs provide a 360° view of the Slip 4 EAA.

EAA – early action area
ID – identification
GPS – global positioning system
NAD83/91 – North American Datum of 1983/1991
NOAA – National Oceanic and Atmospheric Administration

Table 2-2. Year 4 visual inspection summary

Survey Area[a]	Date	Time	Area Substrate Classification	Estimated Thickness of Fines	Stratification	Color	Evidence of Pollution	Organic Matter	Presence of Debris/Litter/Garbage	Assessment of the Re-establishment of Intertidal aquatic Habitat	Wildlife Use Observations	Observations of Cap Disturbance/ Erosion/Changed Condition	Assessment of Cap Integrity
Northeast beach	July 5, 2016	12:20	sand	none observed	sand only, no stratification	gray, brown	none observed	wood debris, logs and leaf/ plant litter	plastic debris, food wrappers	not applicable (not intertidal)	small birds, insects	none observed, thick vegetation	good
Northwest beach	July 5, 2016	11:39	sand	none observed	sand only, no stratification	gray, brown	none observed	wood debris and leaf/ plant litter	plastic debris, food wrappers, cigarette butts	not applicable (not intertidal)	crows, small birds	none observed, thick vegetation	good
North slough	July 5, 2016	11:13	cobble, gravel, sand, silt/clay	2–12 cm	rounded gravel w/occasional riprap, numerous fines deposition areas	gray, black, brown surface	none observed	leaf litter, sticks and branches, filamentous algae	trace plastic debris	barnacles on riprap	bird tracks, crows, one small clam valve	none observed	good
Central slough	July 5, 2016	11:43	cobble, gravel, sand, silt/clay	0 to 19 cm	rounded gravel and riprap w/trace sand and overlying fines	gray, black, brown, brown surface	none observed	trace leaf litter, sticks, filamentous algae	trace plastic	barnacles on riprap	bird tracks	none observed	good
South slough	July 5, 2016	11:52	cobble, gravel, sand, silt/clay	0 to 22 cm	riprap, rounded gravel, trace sand overlying to 6 cm.	gray, black, brown surface	none observed	wood and sticks, trace leaf litter, filamentous algae	plastic bottle	barnacles on riprap	crows, bird tracks, mussel shell	none observed	good
North sediment cap	July 5, 2016	10:43	gravel, silt/clay	1–10 cm	mostly rounded gravel with some riprap, silt in areas of deposition	gray, black, brown, brown surface	none observed	trace leaf litter and sticks, filamentous algae	none observed	possible burrow holes in deposition areas, barnacles on riprap and gravel	crows, bird droppings, flies	none observed	good
Northwest sediment cap	July 5, 2016	11:34	gravel, sand, silt/clay	0 to 7 cm	rounded gravel with fines and sand in interstices below 2 cm	brown, brown surface	none observed	sticks, trace leaf litter, filamentous algae	none observed	possible burrows in sediment deposition areas	crows and bird tracks	none observed	good
East sediment cap	July 5, 2016	10:23	gravel, sand, silt/clay	0 to 3 cm	round gravel in top 10 cm, w/coarse sand below at 3 cm	gray, black, brown, brown surface	none observed	trace leaf litter, sticks and branches	none observed	possible burrow holes in sediment accumulation areas, barnacles	crows, bird tracks	none observed	good
East-central sediment cap	July 5, 2016	12:17	gravel, sand, silt/clay	0 to 12 cm	rounded gravel in top 10 cm, with fines and trace sand at 2 cm depth and below	gray, brown, brown surface	none observed	filamentous algae, trace sticks and branches, trace leaf litter	trace plastic debris	algae beds, barnacles on gravel	crows, dead crab, very small mussel shell and clam shell	none observed	good
Southeast sediment cap	July 5, 2016	10:08	cobble, gravel, sand, silt/clay	0.5 to 2 cm	rounded gravel in top 10 cm, mixed w/medium coarse sand below 2 cm	gray, brown surface	none observed	filamentous algae, occasional leaf litter and sticks	cigarette butts, beer can	barnacles on gravel	crows	none observed	good
South sediment cap	July 5, 2016	12:07	gravel, sand, silt/clay	0 to 2 cm	rounded gravel with sand mixed in below 2 cm depth	gray, brown, brown surface	none observed	filamentous algae, trace leaf litter and sticks	none observed	barnacles on gravel	crows, bird droppings and tracks, small fish in algae beds, dead crab in water	none observed	good

Table 2-2. Year 4 visual inspection summary

Survey Area[a]	Date	Time	Area Substrate Classification	Estimated Thickness of Fines	Stratification	Color	Evidence of Pollution	Organic Matter	Presence of Debris/Litter/Garbage	Assessment of the Re-establishment of Intertidal aquatic Habitat	Wildlife Use Observations	Observations of Cap Disturbance/ Erosion/Changed Condition	Assessment of Cap Integrity
West sediment cap	July 5, 2016	11:57	gravel, silt/clay	3 to 8 cm	rounded gravel in hummocks, with silt below 2 cm depth.	gray, black, brown surface	none observed	trace sticks, barnacle shell fragments, filamentous algae	none observed	barnacles on gravel and nearby riprap	small fish in water among algae beds, crows, great blue heron	none observed	good
North slope cap	July 5, 2016	10:55	cobble, gravel, silt/clay	1–6 cm (9 cm in one area)	riprap and rounded gravel to depth w/ fines at surface	gray, brown, brown surface	trace pockets of surface sheen below riprap	leaf litter, sticks, wood debris, filamentous algae	occasional plastic debris, paper	barnacles on riprap and gravel, possible burrows in sediment accumulation areas	flies, crows, bird droppings, feathers	none observed	good
North slope cap (near the outfalls)	July 5, 2016	11:03	cobble, silt/clay	0 to 6 cm deep (just below riprap)	riprap/cobble w/some fines in interstices	gray, brown, brown surface	none observed	filamentous algae, trace sticks and wood debris, leaf litter	none observed	barnacles on riprap	bird tracks, feathers	none observed	good
Northeast slope cap	July 5, 2016	10:34	cobble, gravel, sand, silt/clay	< 1 mm	rounded gravel overlaying riprap; coarse sand at 2.5 cm below surface, mixed w/in gravel, trace fines/silt at surface below high tide line	brown, brown surface	none observed	sticks/branches, leaf litter, small logs, filamentous algae at high tide line	plastic debris, broken glass, small pieces of Styrofoam	none observed	crows, bird droppings	none observed	good
Northwest slope cap	July 5, 2016	11:25	cobble, gravel, sand, silt/clay	0 to 2 cm	riprap w/ rounded gravel to ~12 cm deep, with coarse sand and trace fines below in interstices	gray, brown, brown surface	none observed	leaf litter, sticks and branches, filamentous algae on riprap up to high tide line	none observed	barnacles on riprap at base of slope	bird droppings	none observed	good
East slope cap	July 5, 2016	10:15	cobble, gravel and sand	< 1 mm	riprap and large rounded gravel to > 10 cm, coarse sand mixed below beginning at 5 cm	brown	none observed	filamentous algae, leaf litter, sticks and large branches	plastic bags, trace food wrappers and cigarette butts	none observed	bird droppings, crows	none observed	good
Southeast slope cap	July 5, 2016	09:52	cobble, gravel, sand, silt/clay	0.5 to 1.5 cm	rounded gravel in top 10 cm, with riprap, some med/coarse sand underneath beginning ~3 cm deep	gray, black, brown, brown surface	none observed	trace leaf litter and sticks, filamentous algae	food/candy wrappers, paper debris	barnacles on riprap and gravel	crows, feathers	none observed	good

[a] The central sediment cap could not be observed during the survey because it was under water.

Following the inspection, inspection-derived waste was handled in accordance with the QAPP (Appendix A of Integral 2013a). Disposable supplies used during the survey, such as paper towels and nitrile gloves, were removed from the site and discarded in a refuse container for disposal at a solid waste landfill. Liquid waste (e.g., phosphate-free detergent solution), used to decontaminate equipment (e.g., ruler, shovel, spoon) and boots, was disposed in the slip.

2.2.2 Field deviations

No deviations from the QAPP (Appendix A of Integral 2013a) occurred during the Year 4 (2016) visual monitoring event. However, additional field observations were made, and an aerial survey was conducted by Windward using an unmanned aerial vehicle (UAV) flying at an altitude of 75 ft with a 16-megapixel camera.

2.2.2.1 Additional field observations

During the field inspection, an Environmental Systems Research Institute (ESRI) application (Collector for ArcGIS[2]) was used to locate the cap sediment sampling locations identified in the LTMRP[3] (Integral 2013a). While sediment samples were not collected for analysis this year, sampling locations were visited to assess the amount of sediment accumulation at the specific coordinates and in the vicinity. This information will be discussed prior to next year's monitoring event to determine whether any changes to sampling locations or sampling depths should be made.

At each station, a flat shovel and a ruler were used to estimate the depth of accumulated fine material on top of the cap. Observations of the substrate, shovel penetration depth, fines type, and thickness and color were recorded in a file created in the Collector application. In areas where deposited material was present, the thickness of the fines was difficult to determine because of the adhesiveness of the material; the fines stuck to the shovel and a clean horizon could not be obtained. Table 2-3 presents the supplemental field observations.

Table 2-3. Supplemental field investigation observations

EAA Sediment Sampling Station ID	Shovel Penetration (cm)	Observed Substrate	Odor	Color	Comments
SC-3-8	10	coarse sand gravel	none	gray	hard to penetrate

[2] Collector is a mobile phone-based application that can be used in conjunction with a Garmin Bluetooth GLO™ portable global positioning system (GPS) GLONASS Receiver. During the survey, GPS accuracies of approximately 1 to 2 m were achieved.

[3] Two of the waterway cap stations (WC-3 and WC-7) remained submerged during extreme low tide and were not accessible.

Table 2-3. Supplemental field investigation observations

EAA Sediment Sampling Station ID	Shovel Penetration (cm)	Observed Substrate	Odor	Color	Comments
SC-3-12	5	coarse sand gravel organic matter	none	gray	edge of grass; grass 1.2 m (4 ft) tall
SC-3-4	13	cobble gravel silt/clay	none	drab olive gray	gravel and rock, some silt mixed in; could not reach sand
SC-2-8	13	gravel cobble	none	gray	clean coarse gravel layer on top
SC-2-12	5	gravel cobble coarse sand	none	gray	hard to penetrate
SC-2-4	8	gravel coarse sand organic matter	none	drab olive	thick orange layer, black under brown; up to 3 cm fines in area
WC-1	13	silt/clay organic matter medium sand	slight H_2S	black	8 cm of black above sand
WC-2	13	gravel coarse sand organic matter	none	drab olive black	1–5 cm fines in area
WC-4	18	coarse sand gravel organic matter	none	drab olive	thickness ranges from 1–3 cm fines
WC-8	15	organic matter gravel coarse sand filamentous algae	slight H_2S	drab olive	filamentous algae; 0-2.5 cm fines mixed with gravel

EAA – early action area
ID – identification
na – not available; the presence of the seaweed made it difficult to measure the fines

2.2.2.2 Aerial survey

A UAV was used to collect aerial imagery of the Slip 4 EAA during the low tide to document the condition of the exposed portion of the cap. A mosaic image of the flight was created from the images collected by the UAV (Figure 2-3). This image and images taken in future years may be used to help identify changes in areas where fine silt has been deposited on the cap. Generally, depositional areas can be determined by comparing the color differences between darker areas, which represent the gravel cap surface, and lighter areas, which represent deposited material. Field observations indicate that the deposited material tends to have a light gray surface approximately 1 cm thick; the remaining depth of the deposit is black.

The data collected created a more detailed (i.e., higher resolution) base map of the EAA. The resolution of the imagery is sufficient to observe changes in depositional areas in the field under low-tide time constraints. The new imagery is also more quantitative than the existing field survey (with horizontal photos) since it encompasses the entire project area.

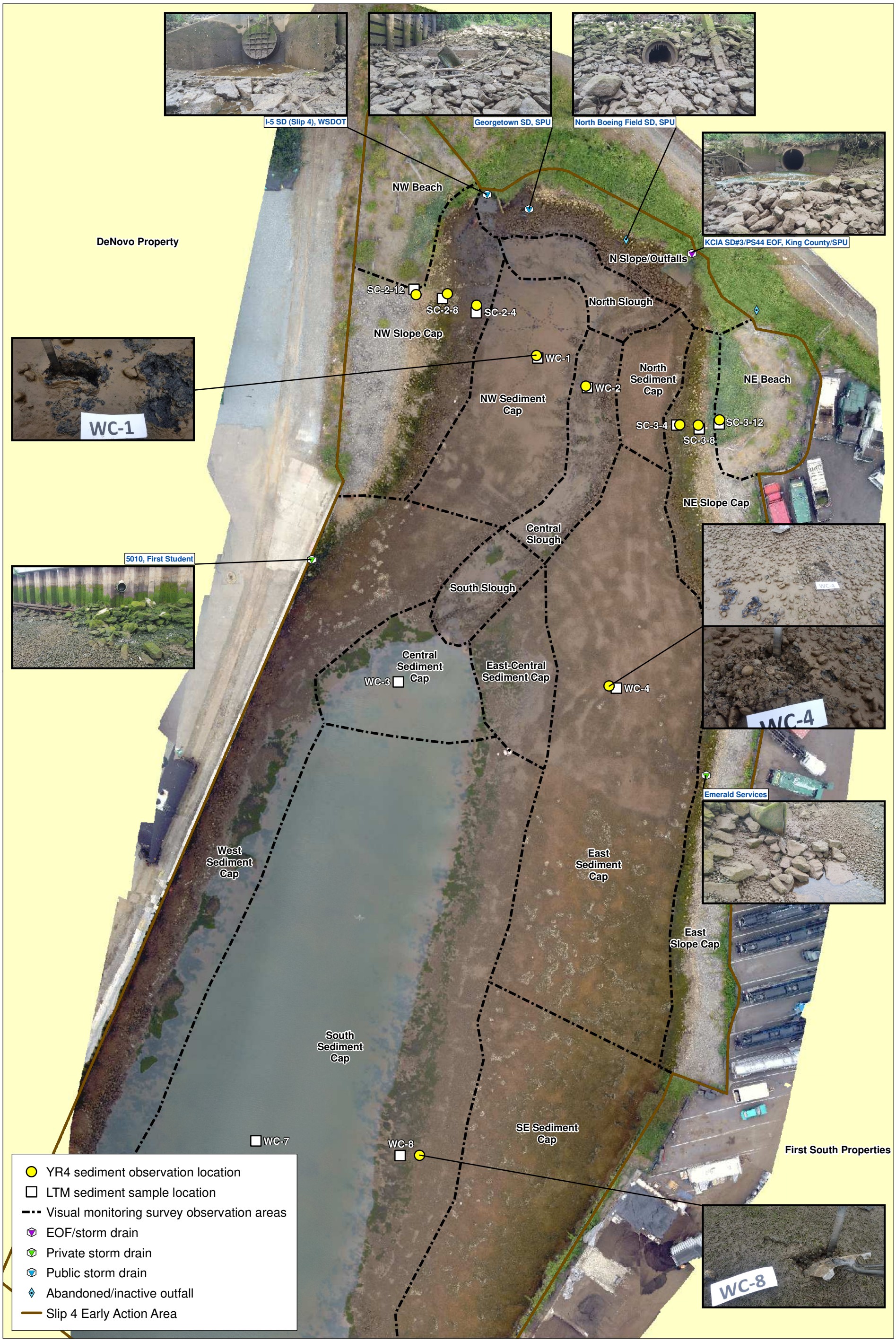


Figure 2-3. Unmanned aerial vehicle (UAV) image with field observation and outfall locations

Prepared by craigh, 1/10/2017; W:\Projects\City of Seattle Slip 4\Data\GIS\Maps and Analyses\Year 4 Data Report\Fig 2-3 6456 Supplemental field obs surv results.mxd

2.3 INSTITUTIONAL CONTROLS REVIEW

The implementation of institutional controls was completed in November 2014 with the final installation of the notification signs at the boundaries of the Regulated Navigation Area (RNA) in the EAA (Integral 2014). Installed at the mouth of Slip 4 and near the sediment cap boundaries, the notification signs inform vessel operators of the presence and prohibit the disturbance of the sediment cap. The signs were examined as part of the Year 4 (2016) long-term monitoring and found to remain in good condition. As of August 11, 2016, the US Coast Guard has received no reports of violations of the RNA (Zappen 2016).

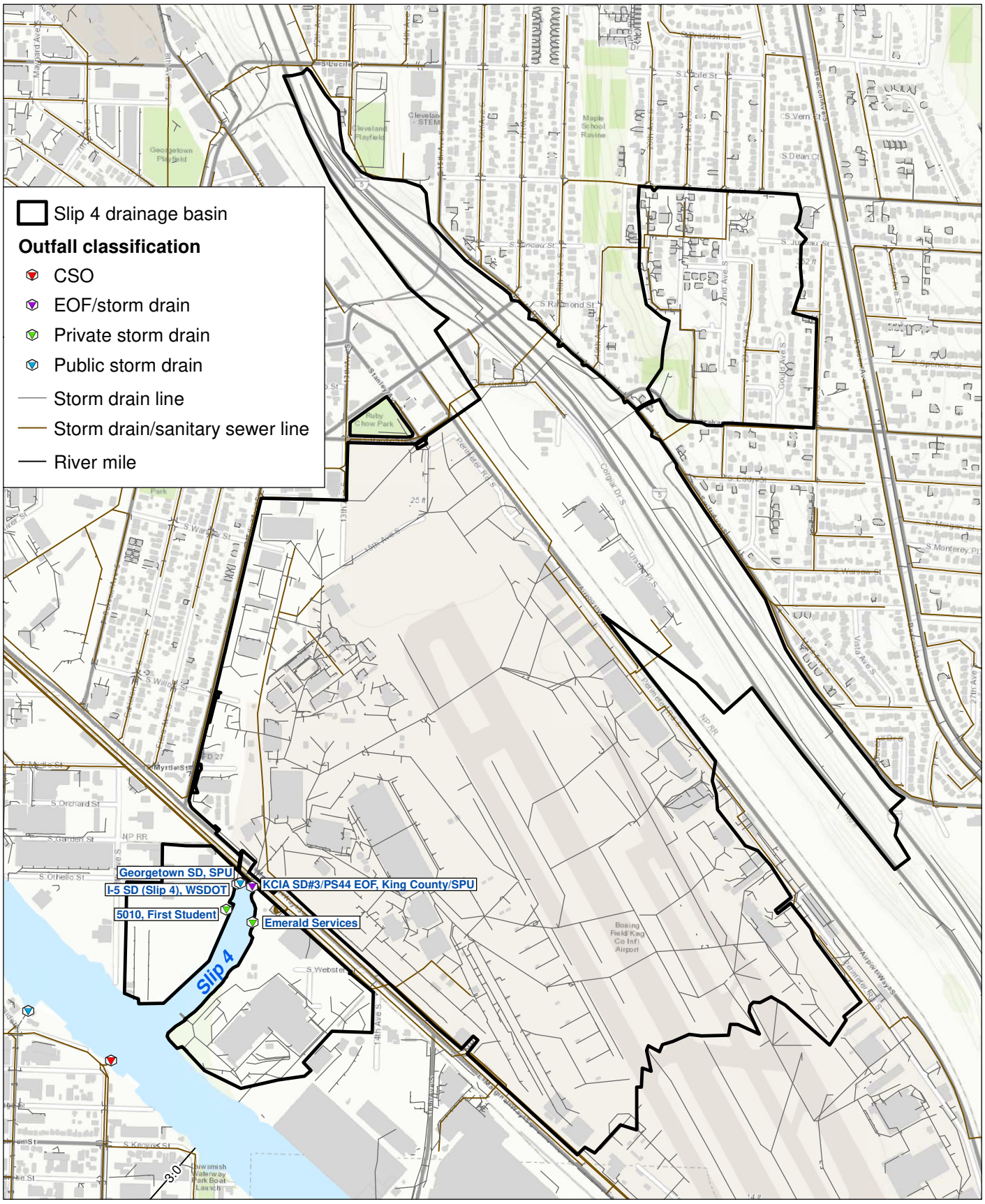
2.4 REVIEW OF OTHER SOURCE CONTROL ACTIVITIES DURING YEAR 4

Four construction activities and other investigations are ongoing within the vicinity of the Slip 4 EAA (Integral 2015):

- NBF RI/FS and LTST operation
- Boeing Plant 2 DSOA corrective measure
- The Washington State Department of Ecology's (Ecology's) NPDES inspection at the Waste Management facility on the DeNovo property, and the Phase 2 MTCA RI/FS on the DeNovo property
- Ecology's NPDES inspection at the Emerald Services facility on the First South Properties property

In addition to these projects, the City has been implementing a source control program for the LDW. Summary updates for these investigations that were performed during the Year 4 (2016) long-term monitoring period (August 2015 through July 2016) are presented in Section 4.2 of this report.

The drainage basins for the three public outfalls and the private storm drain outfalls in Slip 4 is shown on Figure 2-4. The I-5 storm drain collects runoff from 1.5 mi of I-5 (75 ac), 44 ac of residential property east of I-5, and 1 to 2 ac on the north end of KCIA (Ecology 2006). The Georgetown storm drain was installed in 2009 to replace the Georgetown flume. The KCIA storm drain No. 3/SP44EOF drains the northern portion of KCIA and encompasses 290 ac of the Slip 4 drainage area (Ecology 2006).



Windward environmental LLC

Figure 2-4. Slip 4 drainage basin

Prepared by craigh, 12/23/2016; W:\Projects\City of Seattle Slip 4\Data\GIS\Maps and Analyses\Year 4 Data Report\Fig 2-4 6553 Slip 4 source control area.mxd

3 Data Management

Field documentation from the visual inspection was scanned to serve as an electronic record after completion of the fieldwork; this information is presented in Appendices B (photograph log and inspection forms) and D (logbook) and resides on Windward's server. Information from these items was manually entered into data tables and checked for accuracy against hard copies.

As part of the supplemental Collector activities, field data collection forms were built as individual ArcGIS feature layers in order to document station, picture, and depositional area location types for use in ESRI's Collector for ArcGIS. Collector automatically collected and recorded the date, time, and latitude/longitude for each location from the mobile device's GPS. Additionally, each location type had additional fields for recording information specific to that type, and each field was restricted to a specific information type for data entry (e.g., text, numeric data, or date). Where applicable, individual fields were restricted to accepting/selecting specific values (e.g., Yes/No, substrate type, color). These features reduced data entry errors and standardized responses for easier analysis. Each feature layer was also set to accept attachments (e.g., photographs taken using the mobile device's camera) for each recorded location.

A copy of the field data collection forms was uploaded to Windward's ArcGIS Online account and made accessible and editable by the Collector application on the field crew's mobile devices. Field data collected via these forms could be applied directly to the feature layers stored online, or could be stored on the field crew's mobile devices and uploaded later. Upon completion of the survey, the original field data collection forms were exported to a secure read-only copy for archiving. The original collected feature layers can be exported and edited via an ArcGIS Online map interface for review and potential updates/corrections.

When finalized, the collected feature layers were downloaded to Windward's server as a geodatabase for mapping, reporting and analysis. Photo attachments were exported and renamed to maintain their connection to specific features for use outside of the geodatabase. Data tables were downloaded as CSV files for use in Excel® or other applications.

4 Results

This section presents an analysis of the results obtained from the Year 4 (2016) components of the long-term monitoring program.

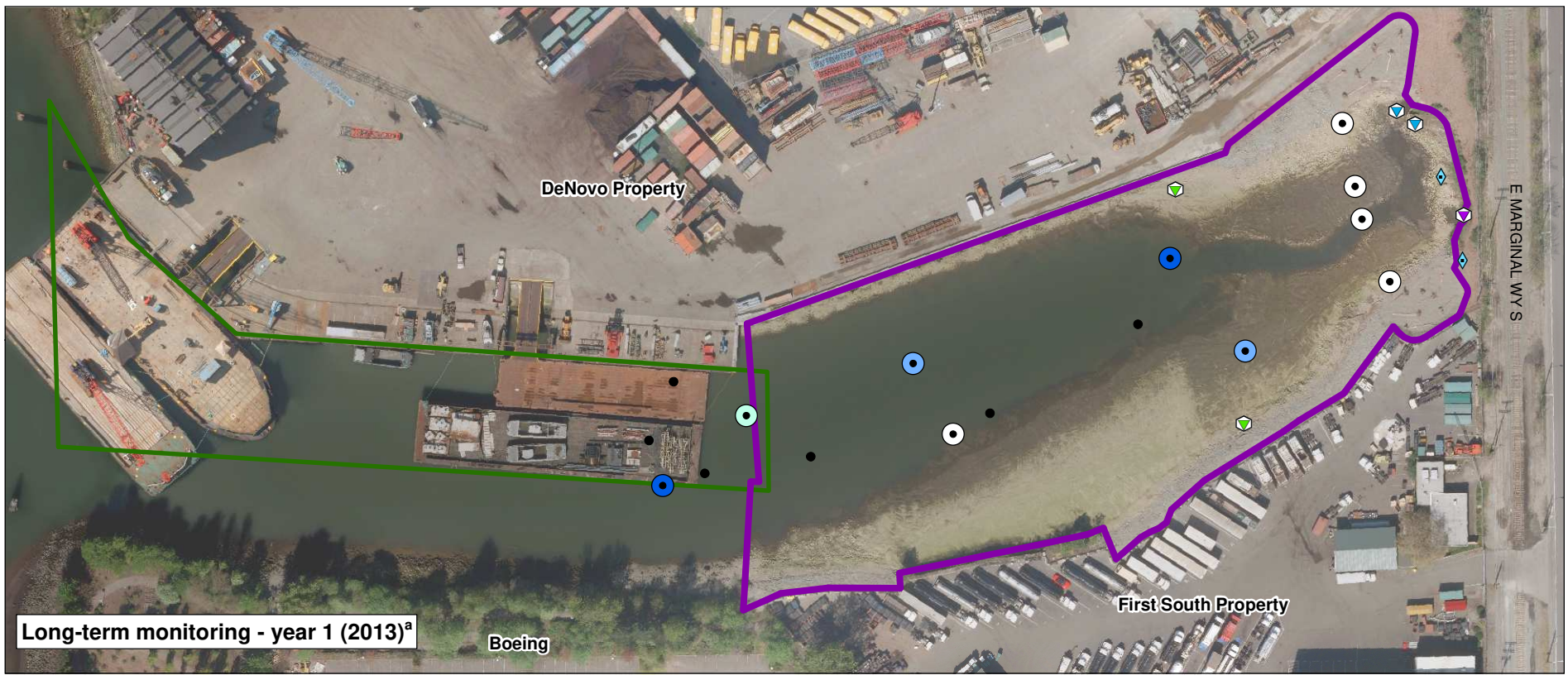
4.1 VISUAL INSPECTION

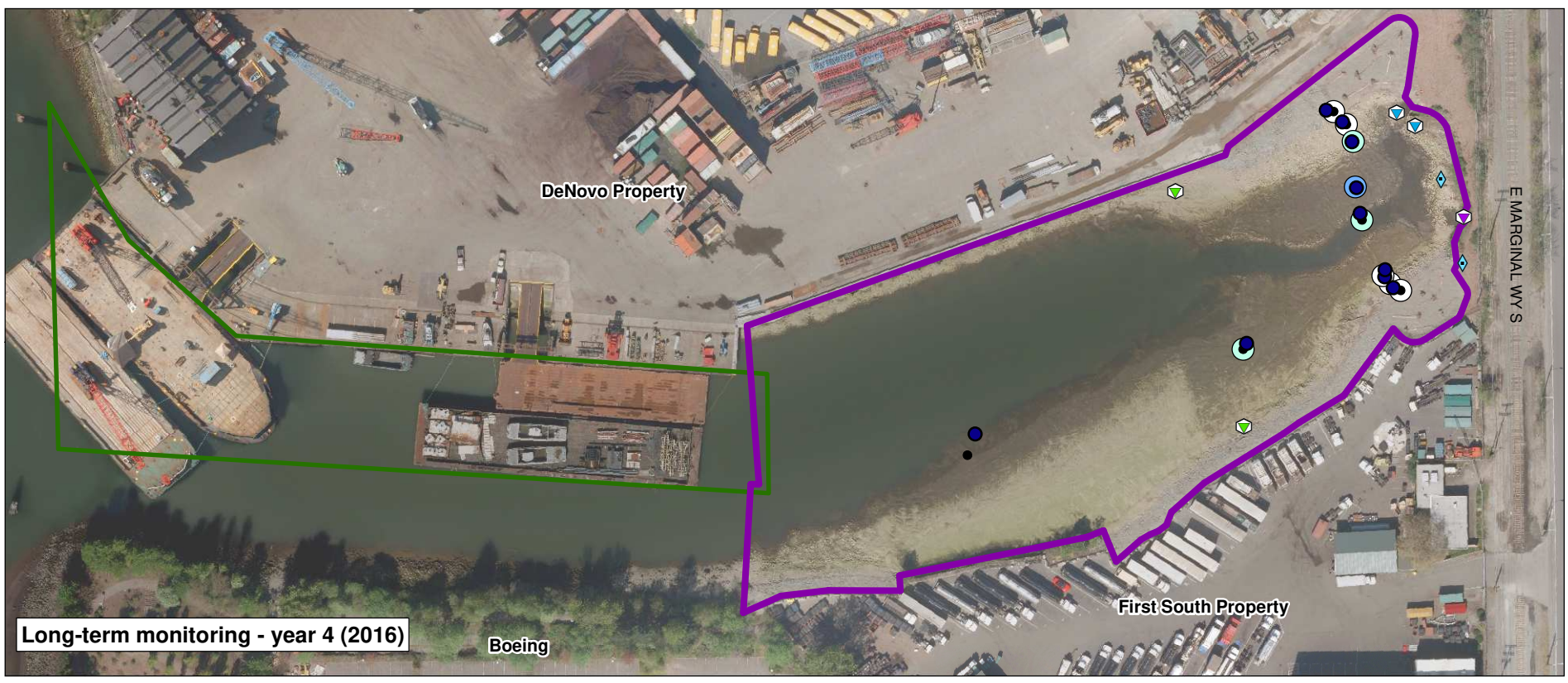
The visual inspection was the primary means of assessing cap integrity, sediment deposition, changes in constructed habitat features, and changes to shoreline development during the Year 4 (2016) long-term monitoring. An evaluation of temporal changes was performed by comparing photographs, field forms, and notes from the Year 4 visual inspection to those from the baseline and previous long-term monitoring surveys. Appendix C2 presents a comparison of visual inspection photos from Year 4 to photos taken from similar vantage points documenting Year 3 (2015), Year 1 (2013) and baseline conditions (2012) following completion of the EAA remedy, when available.

Key observations for Year 4 relative to other years include the following:

- There was no obvious evidence of any adverse impacts on the integrity of the cap (e.g., from slope cap sloughing, erosion from outfall discharges, seismic activity, or breaching from vessel activities or other unauthorized physical disturbances). Changes to the structural integrity of constructed habitat features were also not detected.
- Vegetation observed in the northwest and northeast pocket beaches showed continued growth (e.g., in height and density) relative to observations from previous monitoring years. Small woody and plant debris (e.g., branches, twigs, trace leaf litter) was scattered throughout the EAA. Algae growth was observed along the entire intertidal area.
- Intertidal aquatic habitat continues to re-establish, with limited barnacle colonies attached to riprap, cobble, and gravel in all areas except the east and northeast slope cap areas and northwest beach area (see Figure 2-2 for labeled areas). Possible (invertebrate) burrows were observed in the soft sediment of the east, north, and northwest sediment cap and north slope cap areas. Crab shells were found in east-central and south sediment cap areas, and bivalves (i.e., clams and mussels) were found in the east-central sediment cap and north and south slough areas. Filamentous algae was observed in all areas except the east sediment cap and northwest beach areas.
- Except for some small areas of sheen in the north slope cap area, there was no evidence of pollution in the Slip 4 EAA. The observed sheen may have been humic (e.g., organic nonpetroleum) and caused by bacteria since there were no noticeable petroleum odors.

- Trace litter and plastic debris were observed in some areas, and the occurrence of litter appeared to be more frequently observed (or recorded) than in 2015. Most of the occurrences were located toward the perimeter of the Slip 4 EAA, with fewer occurrences in the intertidal cap areas.
- Similar to previous years, wildlife observations during the Year 4 (2016) long-term monitoring were comprised mostly of avian activity, with insect activity observed less frequently. Commonly observed birds included crows, seagulls, and a great blue heron. Small unidentified fish were also observed at the waterline in the submerged algae beds along the south and west sediment cap areas during low tide.
- Accumulated fine sediment was frequently observed, and accumulation depths varied within small areas throughout the entire Slip 4 EAA (Table 2-2). The aerial images produced by the UAV survey show the patchiness of the distribution of fine sediment throughout the slip, with considerable variability in the thickness of the accumulated sediment within each area (Figure 2-3). In general, there was less accumulated sediment in the slope cap areas and towards the mouth of the slip, except for some mounding of fine material at the base of outfalls on the north slope cap and along the downslope edge of the west sediment cap (Figure 2-3). The slough areas were observed to have some of the thickest accumulation (e.g., up to 22 cm in the south slough). Sediment accumulations in the slough areas appears to have increased since Year 3 monitoring in 2015 (Figure 4-1).





Slip 4 sampling location sediment accumulation thickness (cm)

- No accumulation data
- 0 - 2
- 2 - 4
- 4 - 8
- 8 - 10

Outfall classification

- EOF/storm drain
- Private storm drain
- Public storm drain
- Abandoned/inactive outfall

- Slip 4 Early Action Area
- Crowley dredged area (1996)

Aerial photo: USGS High Resolution Orthoimagery, 1 ft resolution, April 2012.

[a] Integral. 2014. Lower Duwamish Waterway Slip 4 Early Action Area: long-term monitoring data report year 1 (2013). Integral Consulting, Inc., Seattle, WA.

[b] Integral. 2015. Lower Duwamish Waterway Slip 4 Early Action Area: long-term monitoring data report year 3 (2015). Integral Consulting, Inc., Seattle, WA.

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0 25 50 Yards

0 20 40 Meters

Figure 4-1. Sediment accumulation thicknesses on the Slip 4 cap

4.2 OTHER INVESTIGATIONS

This section provides summary updates of information obtained regarding investigations or site activities by other parties identified in or near the Slip 4 EAA during the Year 4 (2016) long-term monitoring period.

4.2.1 NBF RI/FS and LTST

Work on the RI/FS at the NBF/GTSP site is ongoing. The RI fieldwork has been completed and a draft RI report was submitted to Ecology on June 8, 2016 (Bach 2016a). Ecology reviewed the draft report and provided comments on August 12, 2016; Boeing and the City are currently responding to Ecology's comments. Based on the current schedule, the FS report is expected to be submitted to Ecology toward the end of 2017 (Landau 2016).

Boeing operated the fourth year of the LTST system under Administrative Settlement Agreement and Order on Consent (ASAOC) for Removal Action, US Environmental Protection Agency (EPA) Docket No. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) 10-2010-0242, and treated approximately 67% of stormwater volume discharged from NBF and the north end of King County International Airport (Landau 2016); the remainder of the stormwater bypassed the treatment system and was discharged directly to Slip 4.

All whole-water samples collected from the compliance monitoring point (LS431) during the fourth year had PCB concentrations below the marine chronic water quality criterion interim goal of 0.030 µg/L (Landau 2016). Analytical results from samples collected from LS341 are provided in Appendix E1. The ASAOC activities were completed on March 2, 2016. Boeing continues to operate the system as a treatment best management practice under Ecology's industrial stormwater general permit WAR000226 (EPA 2016). Quarterly monitoring results reported no benchmark exceedances or violations (Ecology 2016). PCBs were not analyzed. Monitoring results are available on Ecology's online water quality permitting and reporting information system (PARIS) database.

4.2.2 Boeing Plant 2 DSOA corrective measure

Operating pursuant to the Administrative Order on Consent (AOC) (Resource Conservation and Recovery Act [RCRA] Docket No 1092-01-22-3008(h)) (EPA 2011), Boeing collected surface sediment samples in March 2016 as part of Year 1 of post-construction monitoring. Surface sediment samples were collected from two locations (SD-PCM010 and SD-PCM025) within Slip 4, outside of the Slip 4 EAA (Figure 4-2). A figure presenting the sampling locations and a table with chemistry results provided by Boeing (Bach 2016b) are presented in Appendix E2. In 2016, the PCB concentrations at both locations were below the sediment cleanup objective (SCO) (SD-PDM010 – 46 µg/kg, SD-PDM025 – 8.9 µg/kg). When these locations were

sampled during post-construction sampling in2015, PCBs were not detected at either location.

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N

0 25 50 Yards

0 20 40 Meters

Figure 4-2. Boeing and DeNovo RI sediment sample locations

Photo source: USGS, High Resolution Orthoimagery:2898306_RGB23260025, 3 in resolution, 0.31 ft accuracy. Photo date April 2012.

Prepared by craigh, 12/23/2016; W:\Projects\City of Seattle Slip 4\Data\GIS\Maps and Analyses\Year 4 Data Report\Fig 4-2 6556 Boeing-DeNovo RI locations.mxd

4.2.3 DeNovo property

The DeNovo property is operated by Waste Management as a transloading facility for transferring contaminated soil and sediment from barges to rail cars. Ecology issued an Immediate Action Order in September 2015, which required Waste Management to cease operations until its operations were adequately addressed in a detailed and permit-compliant SWPPP (Ecology 2015). As of September 2016, Waste Management had secured all necessary permits to operate a transloading facility (https://fortress.wa.gov/ecy/gsp/Sitepage.aspx?csid=2520). This property is undergoing an RI/FS under an Agreed Order with Ecology (Ecology 2009, 2014).

A draft RI report was submitted to Ecology for review in August 2016. This document is not available to the public, but Ecology has provided the chemistry results for sediment and other sample media collected in December 2014 (Sutton 2016). Data tables and figures showing the sampling locations in and near the mouth of Slip 4 from the draft RI report are provided in Appendix F (Anchor QEA 2016; Sutton 2016). The sampling locations within Slip 4 are provided on Figure 4-2. These data have been previously discussed in the Year 2 long-term monitoring report (Integral 2014) and the Year 3 long-term monitoring report (Integral 2015).

In addition to the RI/FS, NPDES monitoring has been conducted at the DeNovo property during the Year 4 long-term monitoring period (2015–2016) in accordance with Ecology industrial stormwater general permit WAR302034. Monitoring results are available on Ecology's online water quality permitting and reporting information system (PARIS) database. The monitoring has not required the analysis of PCBs. Benchmark exceedances of zinc, copper, and turbidity, and effluent violations for residue solids/total suspended solids have been reported during this period (Ecology 2016).

In response to NPDES permit violations, including repeated violations observed in November 2014 and August 2015 regarding contaminated soil handling at the site, Ecology issued an immediate action order in September 2015. This order required additional stormwater monitoring in Q4 2015, cleaning of all storm drain catch basins and drainage lines, analysis of solids removed from catch basins near spilled soil, and submittal of an engineering report for providing treatment for all stormwater discharges. Analysis of the catch basin solids samples revealed PCBs concentrations below the SCO, with concentrations ranging from 89 to 180 µg/kg (Appendix F). Metals and PAH concentrations were less than SCOs.

4.2.4 Emerald Services

NPDES monitoring was conducted at the Emerald Services property during the Year 4 long-term monitoring period (2015–2016) in accordance with Ecology's industrial stormwater general permitWAR002641 (Wright 2016). Benchmark exceedances for zinc, copper, turbidity and biological oxygen demand, and one monitoring violation

(for not conducting chemical analysis) were reported during this period (Ecology 2016). PCBs were not analyzed. Results from the conventional monitoring are available on Ecology's PARIS database (https://fortress.wa.gov/ecy/wqreports/public/f?p=110:1:4359631163825274).

4.2.5 City of Seattle

In May 2016, as part of source tracing for the City's Lower Duwamish Pollution Source Control Program, SPU collected one storm drain solids sample from the I-5 storm drain system that drains into Slip 4 (Appendix G) (City of Seattle 2016a, b).

The preliminary unvalidated data for this sample are provided in Appendix G (Schmoyer 2016). Chemicals detected in this sample with concentrations above the SCO included zinc and SVOCs (i.e., bis(2-ethylhexyl)phthalate, 4-methylphenol, benzoic acid and benzyl alcohol). The total PCB concentration in the sample (80 µg/kg) was below the SCO (Appendix G).

5 Conclusions and Recommendations

The objectives of the Year 4 (2016) monitoring program for the Slip 4 EAA were achieved. The monitoring results indicate that the sediment cap remains structurally sound, and sediment continues to accumulate on top of the cap. Physical conditions observed during Year 4 monitoring were similar to those found in previous monitoring years. Fine sediment deposits were observed throughout the cap areas at varying thicknesses. The thickest accumulations were generally observed in the slough areas and along the east-central sediment cap. Based on comparison photos, the sediment fines deposition near the northwestern corner of the slip near the north slough appeared to cover slightly more area than during previous surveys.

The UAV data collected during the supplemental field observations provided useful insight to the sediment fines depositional areas that are difficult to study solely through the established visual survey methods and photographs. To better capture the spatial variability and dynamics of sediment deposition over time, Windward recommends including a UAV survey component in future long-term monitoring efforts, now that a real-time baseline aerial image has been established for the EAA.

As sediment continues to accumulate on the cap, it will be important to carefully assess the monitoring and source data to ensure the continued success of the remedy.

In summary, the results of the Year 4 visual monitoring provide the following answers to the LTMRP questions:

- Are contaminant concentrations in Slip 4 EAA surface sediments (0 to 10 cm) below applicable SQS?

  Chemistry data were not collected as part of the Year 4 monitoring.

- Is the physical integrity of the cap in the Slip 4 EAA being maintained such that the sediment cap continues to isolate contaminants in underlying sediments from marine biota?

  Yes.

- Do the institutional controls associated with the Slip 4 EAA remedy remain in place and continue to work effectively?

  Yes.

- Are physical changes occurring related to sediment erosion and sediment deposition in the Slip 4 EAA?

  Yes. Sediment is accumulating on top of the cap material.

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