DENNY WAY CSO NEARSHORE INTERIM SEDIMENT CLEANUP PROJECT CLOSURE REPORT

Prepared by the
King County Department of Natural Resources and Parks
Wastewater Treatment Division

King County

October 2008

Denny Way CSO Nearshore
Interim Sediment Cleanup Project
Closure Report

Prepared for:
King County Department of Natural Resources and Parks
Wastewater Treatment Division

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October 2008

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1.0 Introduction

This Closure Report documents the work performed during the Denny Way Combined Sewer Overflow (CSO) Nearshore Interim Sediment Cleanup Project in Elliott Bay in Seattle, Washington (Figure 1). Cleanup requirements at the site were more specifically described in the Agreed Order No. DE 5068, dated November 2007, issued by the State of Washington, Department of Ecology (Ecology) and pursuant to the Model Toxics Control Act (MTCA). The remedial activities at the site were performed in compliance with the Washington Administrative Code (WAC), Washington's Sediment Management Standards (SMS) (Ecology 1995, WAC 173-204), and MTCA (Ecology 2001, WAC 173-340). This Closure Report describes the dredging, transport, disposal, and backfilling activities that occurred between November 2007 and February 2008.

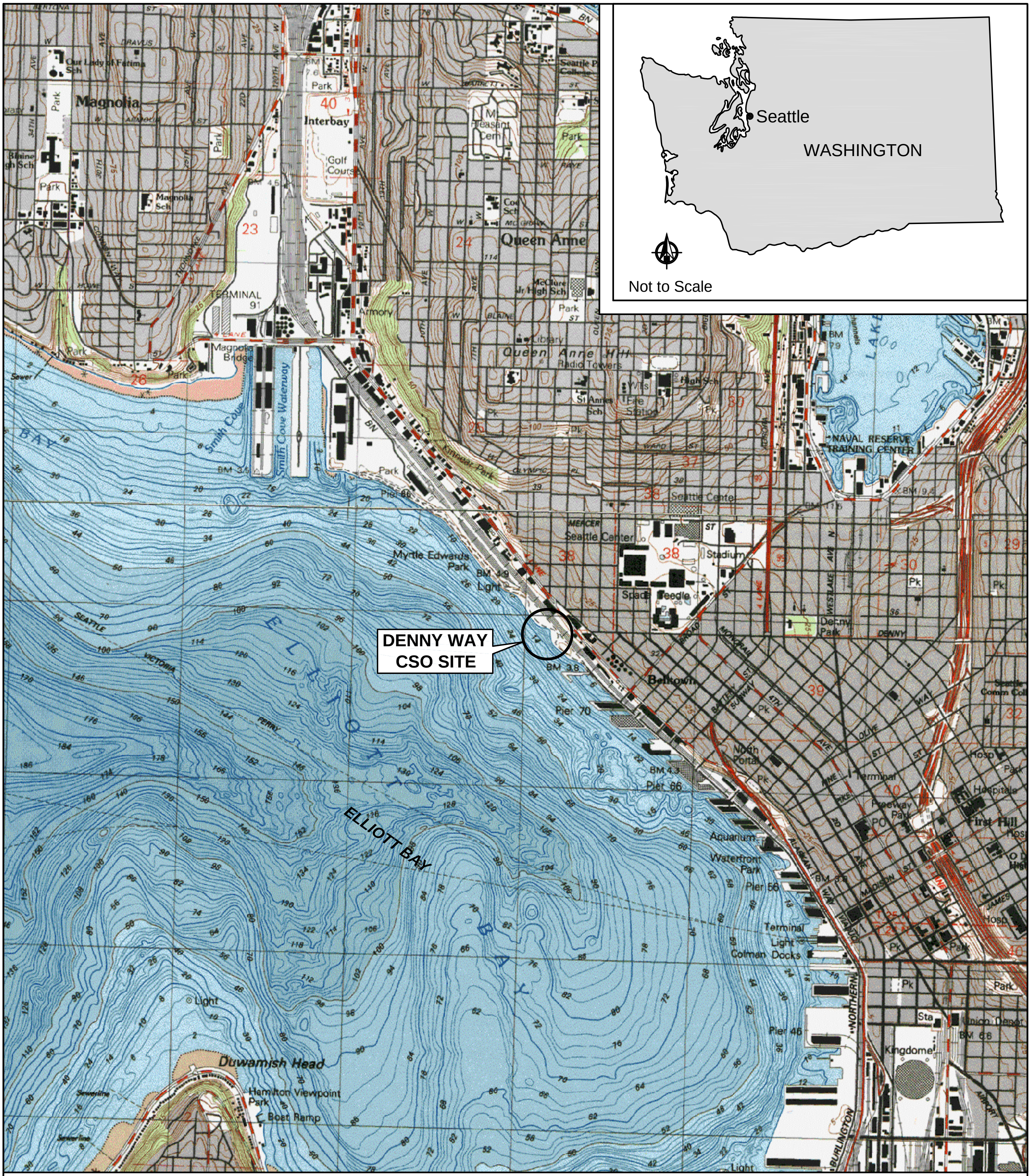
1.1. BACKGROUND

At the turn of the century, raw sewage discharge at the Denny Way site was common until the construction of the Denny Way CSO. The Denny Way CSO was constructed in the 1960s when the Municipality of Metropolitan Seattle (Metro; now King County) built the present system of interceptors and treatment plants that collect, transport, and treat wastewater in the greater Seattle area. The CSO site is located along the northeastern shoreline of Elliott Bay and is adjacent to Myrtle Edwards Park at the foot of Denny Way in Seattle, Washington (Figure 1). The Denny Way CSO regulator station is located at 3165 Alaskan Way. Until 2004, the discharge point of the Denny Way CSO was at the shoreline. This outfall was previously exposed during normal low tide and frequently discharged directly across exposed intertidal sediment. Since 2005, the Denny Way CSO outfall has discharged roughly one untreated discharge annually (approximately 8 million gallons per year) and about 8 to 12 treated discharges (approximately 567 million gallons per year) from a new offshore outfall.

In 1986, Metro began a trial program to identify and reduce toxicant inputs to the sewer system discharging through the Denny Way CSO. In 1990, King County and the U.S. Army Corps of Engineers (Corps) sponsored the Denny Way CSO capping project to test the feasibility of capping contaminated sediments in Elliott Bay with clean dredged material from the Duwamish Waterway. A 3-foot layer of clean sand, dredged from the upper Duwamish Waterway during routine maintenance, was placed over a 3-acre area in water depths ranging from approximately -25 to -60 feet mean lower low water (MLLW).

King County has monitored the effectiveness of the cap at containing contaminated sediment for the past 17 years. Results show that the cap is stable, is not eroding, and has successfully isolated the underlying contaminated sediments (King County 2005).

However, chemical concentrations on the cap surface layer (offshore of the Denny Way CSO) increased after cap construction, suggesting possible recontamination from the continued CSO discharges from Denny Way, or potential redistribution of remaining contaminated sediments from the intertidal area and the inshore edge of the cap.



Note: Base map prepared from Terrain Navigator Pro USGS 7.5 minute quadrangle map(s) of Seattle North and South, Washington.

0 1/2
Scale in Miles

Jun 22, 2008 10:30am cdavidson K:\Jobs\020067-KING_CO_SED_MANAG\02006701\02006701-107.dwg FIG 1

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ENVIRONMENTAL, L.L.C.

Figure 1
Vicinity Map
Denny Way CSO Nearshore Interim Sediment Cleanup Project

In 1997, King County characterized the nature and extent of surface and subsurface sediment contamination in the outfall area, as well as areas inshore and offshore of the existing sediment cap (SEA 1997). Follow-up sediment sampling conducted by King County in 2005 demonstrated that chemical concentrations in the offshore areas declined over time due to a combination of natural processes, including biodegradation of chemicals, accumulation and mixing of clean sediment, and reduction of contaminant sources (King County 2005). Thus, monitored natural recovery is a prospective cleanup remedy for the offshore areas. These areas will continue to be evaluated by Ecology and King County to determine if a more active cleanup remedy is required.

In 1997, sediments sampled within inshore areas of the site contained concentrations of cadmium, copper, lead, mercury, silver, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), bis(2-ethylhexyl)phthalate, and butyl benzyl phthalate that exceeded Sediment Quality Standards (SQS) chemical criteria. Contaminant concentrations above SQS chemical criteria were present to a depth of approximately 10 feet below the existing mudline. Unlike offshore areas of the site, natural recovery rates in the inshore sediment areas appeared to be progressing relatively slowly. In order to accelerate cleanup of the site and minimize the risk of future recontamination to other site areas, including the offshore cap, an interim sediment cleanup action plan for the site was developed by King County and Ecology in 2007, including dredging to the maximum extent practicable to remove impacted sediments, and backfilling to restore the grade to close to pre-project conditions.

The Denny Way CSO interim action remediated contaminated sediment present in two nearshore areas in the immediate vicinity of the former Denny Way CSO outfall (Areas A and B). A combination of dredging, backfilling, and armoring was employed to remediate the nearshore areas.

In the initial design, approximately 17,000 cubic yards (cy) of contaminated sediments and associated side slopes were to be dredged from approximately +10 feet MLLW to approximately -35 feet MLLW within the 1.2-acre interim action area. A change order during dredging decreased the overall dredge footprint by over-steepening the side slopes to minimize the disturbance and removal of the riprap seawall. After the change order, approximately 13,700 cubic yards (cy) of contaminated sediments and associated side slopes were dredged. The material within the dredge footprint was mechanically dredged using a clamshell bucket deployed from a derrick barge. Removal of rock armor and concrete from the seawall was performed with a barge-mounted excavator and 414 tons of recyclable concrete material was recovered from 1,918 tons of mixed concrete, rock, and sediment. The dredged area was backfilled and armored with an average thickness of more than 8 feet of material. Approximately 11,886 cy of well-graded clean sand was armored with approximately 4,821 cy of sandy-gravel habitat mix, as well as large cobbles and boulders. An additional 1,540 cy of well-graded clean sand was placed in an approximate 6-inch-thick layer around the perimeter of the dredge prism to address any residuals that may have resulted from the dredging.

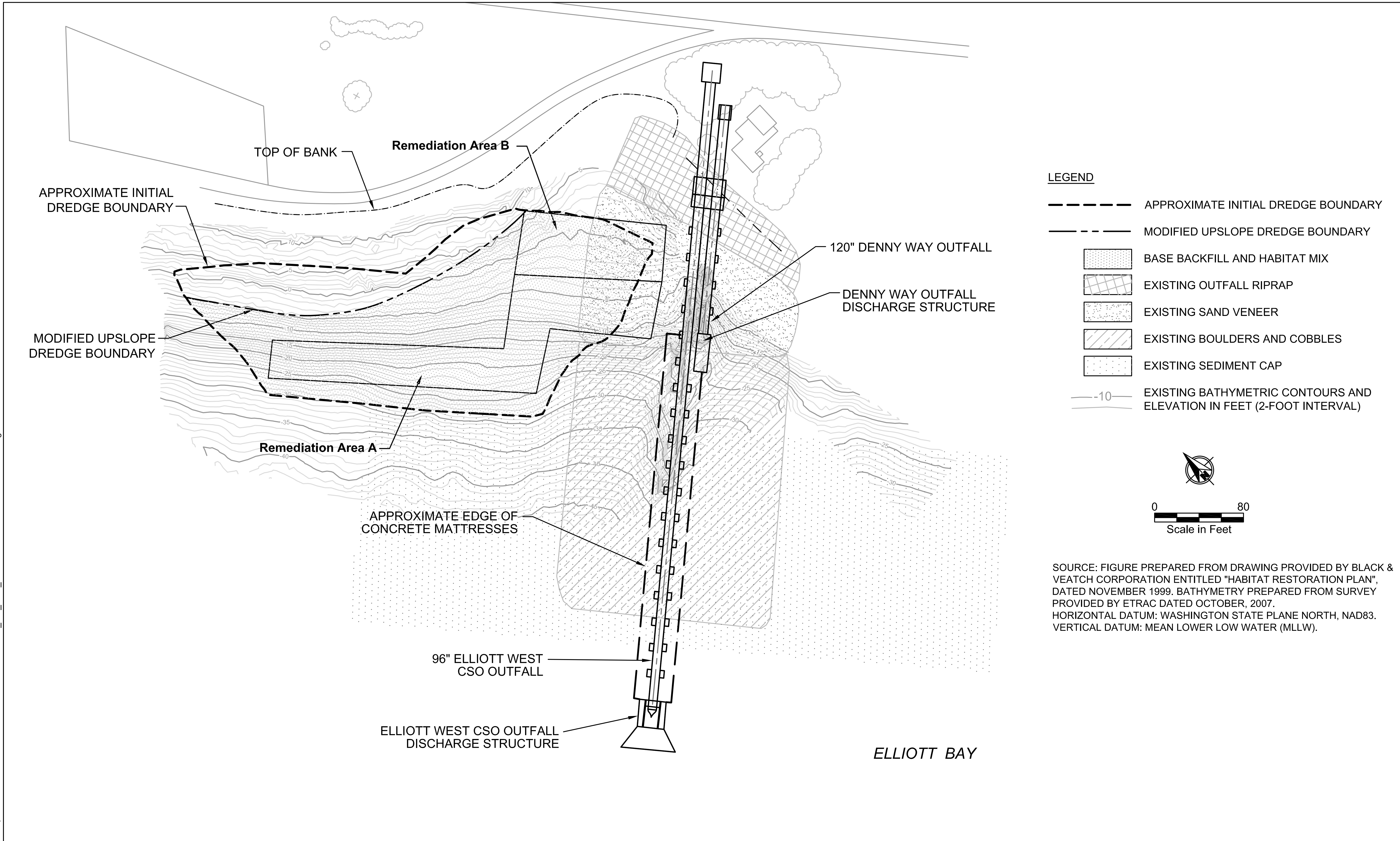
This Closure Report discusses the construction activities performed to implement the cleanup.

1.2. OBJECTIVES

The objective of the project was to remediate contaminated sediment in two inshore remediation areas (Areas A and B) in the immediate vicinity of the former Denny Way CSO outfall that exceeded SQS chemical criteria promulgated under the SMS. The two rectangular cleanup areas (Areas A and B) are adjacent to each other and are located immediately offshore of the Denny Way historical CSO as shown in Figure 2. Cleanup Area A is the larger of the two areas at about 0.48 acres, and is located offshore and adjacent to Area B. Cleanup Area B is smaller in size at about 0.16 acres, and is located immediately offshore of the Denny Way historical CSO. Sediments in both cleanup areas had concentrations that exceeded SQS chemical criteria for mercury, silver, cadmium, copper, lead, PCBs, PAHs, bis(2-ethylhexyl)phthalate, and butyl benzyl phthalate. The extent of contaminated sediment removal for the site is shown in Figure 2. As previously discussed, the 1997 sediment characterization study identified contaminants at concentrations above SQS chemical criteria in Areas A and B to a depth of 8 feet below mudline (SEA 1999). More recent characterization (Anchor 2005) indicated that contaminated sediments are present at depths greater than 10 feet.

The vertical limit of the dredge prism was the maximum practicable removal, which entailed a sloping dredge cut on the order of 10 feet deep. Deeper dredging would have required removal of large areas of the existing upland shoreline, which was not considered practicable without adverse impact on the Myrtle Edwards Park shoreline. The southern boundary of the project was constrained by the presence of the existing outfall structures (and armoring) and the dredge prism here was offset to avoid impacting these features.

The cleanup action for Areas A and B involved first removing contaminated sediment from both cleanup areas to the maximum extent practicable, followed by placing a layer of backfill material. The remaining contaminated sediments within each cleanup area were covered with an average of 8 feet of backfill material (maximum of 13 feet) to isolate the remaining chemicals from the environment and return the site to approximately the bottom elevations that existed prior to dredging.



Jun 23, 2008 11:45am cdavidson K:\Jobs\020067-KING_CO_SED_MANAG\02006701\02006701-116.dwg FIG 2

Figure 2
Cleanup Areas A and B
Denny Way CSO Nearshore Interim Sediment Cleanup Project

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2.0 Construction Activities

2.1. TIMELINE

The contractor began mobilizing their equipment to the site on November 29, 2007, and started dredging on November 30, 2007, at about 12:30 p.m. Dredging was conducted from November 30, 2007, to January 12, 2008. Backfilling was conducted from January 17 to February 25, 2008. The contractor demobilized from the site on February 26, 2008.

2.2. CONTRACTOR SELECTION

The Request for Bids to construct the Denny Way CSO Nearshore Interim Sediment Cleanup Project was advertised in the Seattle Times, other local newspapers, and the King County Procurement website. A pre-bid conference was held on August 22, 2007, in the eighth floor conference room of the Exchange Building at 821 Second Avenue in Seattle. Sealed bids were required to be submitted to King County at the third floor Contracts Counter at the New County Office Building by 1:30 p.m. on September 25, 2007.

Two bids were received and were opened on September 25, 2007. The lowest responsive bid was submitted by American Civil Constructors West Coast, Inc. (ACC), of Seattle, Washington, for $3,276,234. The engineer's estimate for this project was $3,250,000. ACC was selected as the prime contractor and Notice to Proceed was issued on November 9, 2007.

2.2.1 Lessons Learned

Contractor selection was largely influenced by prequalification requirements implemented by King County to limit participation during the bidding process to contractors with substantial experience dredging contaminated sediments. Bids were also limited by insurance requirements set by King County. Comments received during the pre-bid period expressed concern regarding the specifications, and, also indicated that the construction window was too short to complete the work, and that there were too many amendments during the bid process. Other active construction contracts at the time of bidding may also have impacted contractor participation.

2.3. GENERAL CONSTRUCTION PROCEDURES

The contractor was required to dredge using a clamshell bucket and dredge beginning with the inshore, higher elevation material, and then move offshore. Sloughing of slope material and the spread of contaminated sediment was minimized by dredging generally from upslope to downslope. As designed, the dredge prism included a substantial amount of shoreline armor material overlying potentially clean sediment upslope of the Area A and B boundaries to accommodate stable dredge cut side slopes. During construction, the contractor indicated that steeper stable side slopes could be achieved, which would have reduced the volume of clean side slope armor and additional side slope material dredged to accommodate the remedy. In consideration of this factor, a change order (RCO No. 001) was issued by King County featuring a revised dredge prism footprint and including removal and disposal of concrete debris, and replacement of armor rock on the upslope portion of the dredge prism. The change order was accepted by Ecology to be consistent with the cleanup action.

When dredging operations were complete, the contractor was allowed to begin backfilling operations. The backfill consisted of two different layers. A base backfill layer primarily composed of sand was placed first to cover all remaining sediment contamination. This was followed by a more erosion-resistant surface layer of larger sized habitat mix. Finally, armor rock was placed in areas where it had been removed along the seawall and contingency cover sand was placed in areas where dredge residuals may have migrated outside the dredge prism boundary.

King County provided construction management, inspection of all construction activities, and water quality monitoring services throughout the project.

2.4. DREDGING OPERATIONS

2.4.1 Equipment

The contractor mobilized a derrick (*Pam Tay*), tug (*Jennifer H*), flat-deck barges (*KP-1, KP-2,* and *H-9*), work skiff, and hydrographic survey vessel to the site. The *Pam Tay* is 200 feet long by 50 feet wide, with a 12-foot draft. It is equipped with an American 9310 crawler crane with a 3-cy clamshell bucket. The derrick is equipped with a differential global positioning system (DGPS) with an antenna on the tip of the boom over the bucket. Dredgepack® software was used to allow the operator to know where the horizontal position of the bucket was relative to the dredge plan at any given time. The vertical position of the dredge bucket was determined by 1-foot markings on the cable and an electronic tide gauge that displayed real-time tide information. The *Pam Tay* was typically positioned using two spuds measuring 90 feet in length, and when spuds were not used, a mooring winch and anchor system was used off the stern of the *Pam Tay*. The spuds were positioned outside of the dredge boundary and no spuds were placed inside the dredge prism. The small tug (*Jennifer H*) periodically moved the *Pam Tay* so the derrick could be repositioned within the dredge prism.

Dredged sediment was placed in one of three flat-deck barges that were brought onto the site at different times (*KP-1*, *KP-2*, and *H-9*, with 2,000-cy capacity each) and taken to the offloading facility for offloading, transport, and disposal. Scuppers on the flat-deck barges were covered with filter fabric and hay bales, which filtered suspended solids from dewatering effluent before re-entering Elliott Bay.

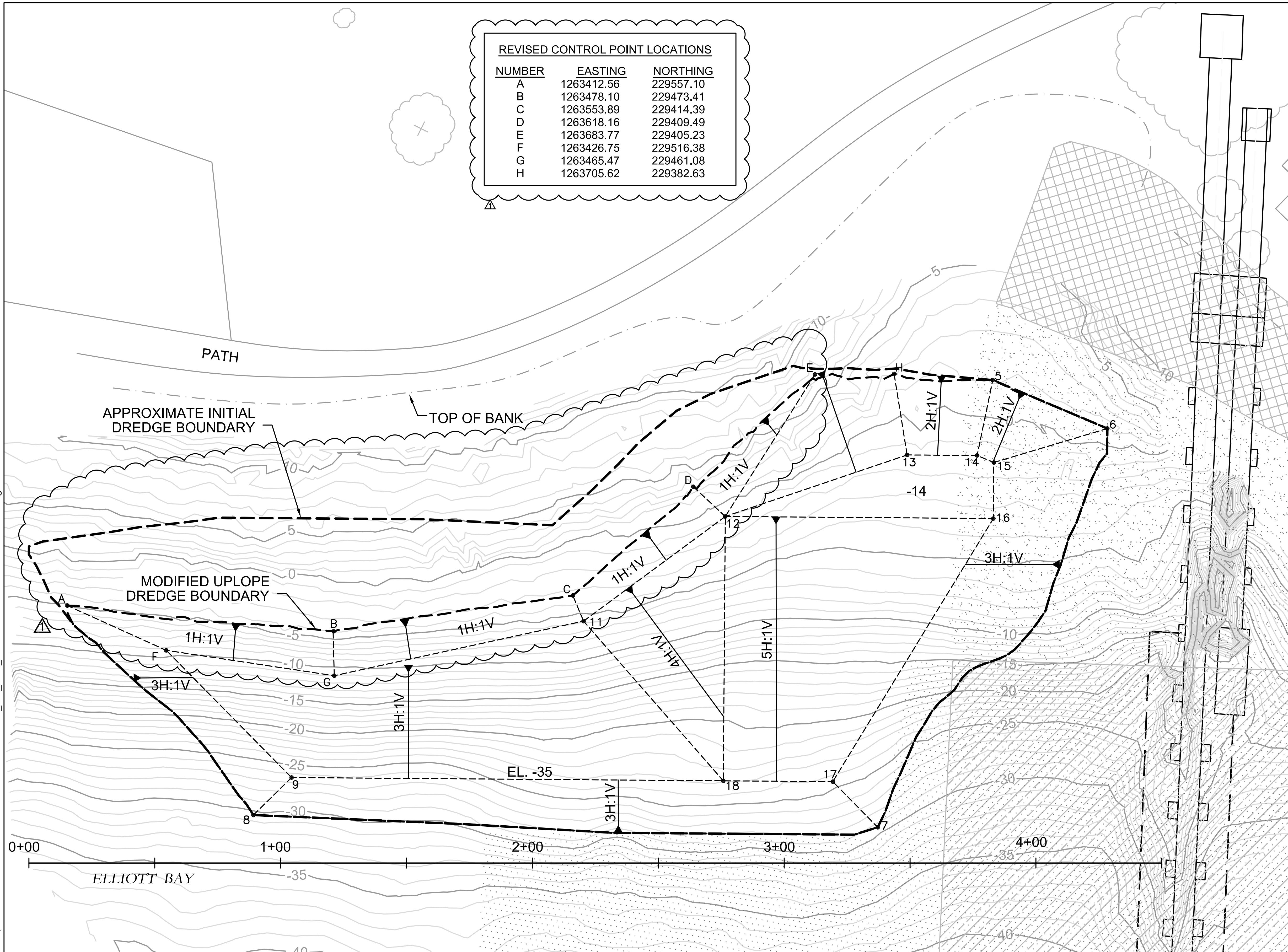
From the start of dredging activities, the contractor encountered difficulty using the 3-cy dredge bucket to remove armor rock and concrete on the upslope portion of the dredge prism along the seawall. Change order RCO No. 001 instructed the contractor to remove armor rock and concrete on the upslope portion of the dredge prism. To complete the change order work, the contractor mobilized a barge-mounted excavator (*Hitachi EX800H* and *34 Spud Barge*) with the tug *Diane H*, and a material barge (*ITB-166*) for the removal and stockpiling of armor rock and concrete debris. The additional equipment was on site for 13 days until the concrete debris had been sufficiently removed from the dredge prism. Concrete armor material that was removed was stockpiled on the barge for transfer to a concrete recycling facility.

There were no upland contractor support equipment and facilities at the dredge site. The contractor stored the derrick, barges, and equipment on site at an offshore location in the vicinity of the dredge prism. Personnel were transferred on and off the derrick and barges by boarding from the shore using a work skiff. The King County inspector was set up in the construction trailer located shoreward of the Denny Way CSO regulator station and continuously monitored dredging from the trailer located on shore.

A turbidity exceedance was observed once during the dredging operations and is discussed further in Section 3.1.1.1. Although only one water quality exceedance occurred during dredging, actions were taken as necessary in an attempt to reduce turbidity throughout dredging whenever the monitoring equipment noted a rise in turbidity. Such actions included slowing the rate of dredging, slowing the rate of bucket movement through the water, not overfilling the bucket, and periodically pausing and resuming work operations.

2.4.2 Sequencing

The dredge plan is shown in Figure 3. On November 24, 2007, before dredging work had been initiated, the contractor submitted a letter to King County stating that there was a change of conditions at the site due to a large volume of concrete and debris present on the upslope portion of the dredge prism. At about 12:30 p.m. on November 30, 2007, the contractor began dredging the northern inshore area of the dredge prism between stations 1+00 and 1+75. The contractor identified rock and concrete armor material from the inshore dredge prism boundary at elevation +10 feet MLLW down to elevation -5 feet MLLW. The contractor attempted to remove armor material, but progressed slowly with the 3-cy bucket because the bucket had difficulty picking up the concrete material. The approximate area of rock and concrete armor was previously delineated by contractor surveys and the contractor continued to dredge downslope of the rock and concrete armor area between elevations -5 and -35 feet MLLW. Dredging generally occurred in the upslope to downslope direction to maintain slope stability and moved from north to south within the dredge prism (from stations 0+00 to 4+50). The width of each dredge pass was approximately 50 feet wide and the dredge cut was typically between 2 to 4 feet deep. The time to complete a dredge cycle was, on average, 1 minute 30 seconds for the dredge operator to position the clamshell bucket, lower the bucket to the sediment surface and take a bite of sediment, raise the bucket above the water surface, and release the material onto the flat-deck barge.



REVISED CONTROL POINT LOCATIONS

NUMBER	EASTING	NORTHING
A	1263412.56	229557.10
B	1263478.10	229473.41
C	1263553.89	229414.39
D	1263618.16	229409.49
E	1263683.77	229405.23
F	1263426.75	229516.38
G	1263465.47	229461.08
H	1263705.62	229382.63

LEGEND

- EXISTING OUTFALL RIPRAP
- EXISTING SAND VENEER
- EXISTING BOULDERS AND COBBLES
- EXISTING SEDIMENT CAP
- -10- EXISTING BATHYMETRIC CONTOURS AND ELEVATION IN FEET (2-FOOT INTERVAL)
- 6 DREDGE COORDINATE
- DREDGE BOUNDARY
- -14 REQUIRED DREDGE ELEVATION IN FEET (MLLW)

NUMBER	EASTING	NORTHING
~~1~~	~~1263419.05~~	~~229584.32~~
~~2~~	~~1263568.48~~	~~229439.52~~
~~3~~	~~1263633.11~~	~~229435.36~~
~~4~~	~~1263706.89~~	~~229384.31~~
5	1263730.85	229352.56
6	1263748.29	229306.31
7	1263570.67	229263.18
8	1263403.26	229446.17
9	1263424.46	229445.48
10	1263427.34	229534.53
11	1263549.42	229404.29
~~12~~	~~1263618.36~~	~~229392.15~~
13	1263685.87	229356.69
14	1263704.89	229336.40
15	1263707.42	229329.68
16	1263691.18	229314.46
17	1263571.49	229288.62
18	1263541.75	229320.35

NOTES:
1. FIGURE PREPARED FROM DRAWING PROVIDED BY BLACK & VEATCH CORPORATION ENTITLED "HABITAT RESTORATION PLAN", DATED NOVEMBER 1999.
2. BATHYMETRY PREPARED FROM SURVEY PROVIDED BY eTRAC DATED OCTOBER 2007.
3. HORIZONTAL DATUM: SP NAD 83 WA N
4. VERTICAL DATUM: MLLW

⚠ MODIFICATION TO DREDGE DESIGN

0 40
Scale in Feet

Jun 24, 2008 10:46am cdavidson K:\Jobs\020067-KING_CO_SED_MANAG\020067010\02006701-117.dwg FIG 3

Figure 3
Dredge Plan
Denny Way CSO Nearshore Interim Sediment Cleanup Project

On December 18, 2008, King County issued a change order (RCO No. 001) that reduced the dredge prism side slope footprint and minimized the removal of armor rock and concrete on the upslope area by changing the dredge cut from the design 2 horizontal to 1 vertical (2H:1V) slope to a 1H:1V slope cut, which was demonstrated to be stable by the contractor. The change order scope of work also included the replacement of the seawall armoring. On December 28, 2008, the barge-mounted crane was mobilized onto the site to remove armor rock and concrete material within the modified dredge prism. It was anticipated that the excavator would pick up pieces of armor rock and concrete material and stockpile them in a separate barge. The excavator bucket frequently picked up a mixture of sediment and some small debris, and there was noticeable sediment loss from the excavator bucket. The material barge *ITB-166* used to stockpile the armor rock and concrete material had a high perimeter fence, which contributed to sediment loss from the excavator bucket because clearing the high fence increased winnowing of material from the excavator bucket. During the use of the excavator, turbidity was visibly higher and the one turbidity exceedance during dredging activities occurred during its operation (see Section 3.1). The excavator was operated from January 3 to January 8, 2008, and removed approximately 1,636 tons of mixed concrete, rock, and sediment. The *ITB-166* material barge left the site on January 8, 2008, and was loaded with 1,087 tons of mixed material. Armor rock and concrete removal activities continued until January 10, 2008, with the clamshell, and an additional 282 tons of mixed concrete, rock, and sediment were removed. The excavator remained on site until January 15, 2008. A total of 1,918 tons of mixed concrete, rock, and sediment was removed and 414 tons of concrete were recovered and transferred to a concrete recycling facility. The remaining material was transferred to the disposal site.

On January 9, 2008, dredging activities with the 3-cy clamshell bucket resumed between station 2+50 and 4+25 and proceeded to dredge remaining high spots in the dredge prism. The contractor performed a cleanup pass on January 12, 2008. The post-dredge confirmatory survey (see Section 4.1) conducted on January 13, 2008, showed relatively minor high spots above the required dredge line along with relatively minor low spots below the non-paid allowable overdepth line and was accepted as complete by the engineer and Ecology. Photos of the dredging and construction activities, contractor daily reports, and King County Inspector reports are located in Appendices A, B, and C, respectively.

The contractor typically worked 10- to 12-hour days including Saturdays during the dredging phase of the project. Dredging typically occurred from 7:00 a.m. to 4:00 p.m. Weather days and equipment maintenance days accounted for approximately 3 days of lost time during dredging activities. The rate of dredging was limited by the rate containers could be loaded onto trains by Rabanco. Therefore, the offloading subcontractor, could not unload the material barges and transfer material to containers at a rate higher than approximately 800 cy per day. There were 5 holiday days when no work occurred during dredging.

Dredging occurred over 32 days and removed approximately 14,376 cy of material (including debris and overdredge). The contractor spent approximately 179 hours dredging the 14,376 cy of material. This time only includes actual dredging time and equates to a gross production rate of 80 cy per hour. The total production time to dredge the 14,376 cy was 348 hours. This time includes dredging, equipment movement, maintenance, downtime, and other non-productive time. Therefore, the net production rate was 41 cy per hour.

2.4.3 Lessons Learned

From a design standpoint, the lessons learned are associated with change order RCO No. 001, which was required in part due to potential misinterpretation of the design plans by the contractor. The following are some of the lessons learned associated with the change order:

- The design plans did not demarcate an approximate area of the existing armor rock and concrete on the upslope portion of the dredge prism, leaving the contractor to determine the extent of the armor based on a description in the Technical Specifications and a pre-bid site investigation required of the contractor by the Contract Documents.
- In addition to delineating the area of armor rock and concrete on the plans, it may have been beneficial to make the removal, stockpile, and/or disposal of the armor rock and concrete a separate bid item so that the contractor's interpretation of the scope for that portion of the work could be evaluated.
- Additional site characterization information could have been collected by King County so that the delineation of the armor rock and concrete was better known.
- The change order reduced the dredge prism to minimize the removal of armoring material, which worked well in this situation because the contractor was able to demonstrate that material would not slough or fail at the proposed 1H:1V slope. However, because a temporary slope as steep as 1H:1V is typically only marginally stable in a marine environment, designing a dredge prism using side slopes as steep as 1H:1V would have been non-conservative during design, and could have resulted in under-predicting dredge volumes. This would potentially lead to negative impacts on permitting and project cost.
- The contractor used an excavator with limited success to execute the change order and presented no alternate solution other than using the clamshell to continue dredge work. The change order could have included language that based payment on a specified level of performance, such that there is more risk sharing between the contractor and King County.

In addition, contractor daily progress surveys were not performed and, consequently, the progress surveys were performed generally at the contractor's discretion unless specifically requested by King County. The contractor requested reduction in survey frequency because of safety concerns with the small surveying boat. The contractor's progress surveys should be strictly enforced to adequately monitor dredging progress, slope stability, and overdredging below the allowable overdepth line established in the

Technical Specifications. Low spots in the dredge prism may have been generated by the removal of large debris pieces to meet the minimum elevation.

In general, the Technical Specifications were viewed by project personnel as containing adequate language that strengthened the ability to control the contractor's methods, water quality, and achieve good performance without hindering project progress.

2.5. DISPOSAL ACTIVITIES

The offloading and disposal operation was performed by the contractor under a subcontractor agreement with Rabanco. Figure 4 shows the layout of the offloading facility, located at the Duwamish Marine Center located at 16 S. Michigan in Seattle, Washington. The Duwamish Marine Center property is permitted to handle bulk material and contaminated waste and had been used previously to unload dredged material from barges to containers.

Dredged sediments were removed from each barge with a front-end loader, which transferred sediment directly into a lined, 20-foot open-top intermodal shipping container. The front-end loader and container were placed onto the dredge material barge in a small cleared area left open by the dredge operator, and typically positioned in the center of the barge. The liner used to line the shipping container was a 6-mil liner and was secured to the top of each container to prevent leakage. To prevent spillage out of the top, each container was limited to about 30 tons of sediment (approximately two-thirds full) to allow for adequate free board. Once filled, the container was removed from the flat-deck barge by a land-based crawler crane. The crane was positioned over the container and four cables were secured to the corners of the container before lifting the container off the barge and placing it either directly onto a truck or on the ground in the transloading dock area. The process of transferring sediment into a container and offloading the container onto a truck was at an approximate rate of 5 containers per hour.

A spill plate between the material barge and the offloading dock was not necessary because the system of loading containers on the material barge precluded the need for a spill plate and eliminated the possibility of any material being spilled during the offload and transfer process.

Pacific Freight Express, Inc., a King County-approved Small Contractors and Suppliers Firm, hauled the containers loaded with sediment to the Rabanco-operated Recycling and Transfer station located at 2733 Third Avenue S. Seattle, Washington, where the containers were loaded onto railcars.

Burlington Northern Santa Fe Railway Company (BNSF) then transported the loaded containers to Roosevelt, Washington, in Klickitat County, for disposal at Roosevelt Regional Landfill, a Resource Conversation and Recovery Act (RCRA) Subtitle D landfill. A total of 21,238 tons of sediment and debris were disposed of at Roosevelt Regional Landfill. The resulting weight to volume conversion factor was approximately 1.5 tons per cy.

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Figure 4
Offloading Facility
Denny Way CSO Nearshore
Interim Sediment Cleanup Project

2.6. DECONTAMINATION

The haul barges were decontaminated at the offloading facility with the use of a front-end loader and manual labor to scrape and remove all sediment on the barge deck and place it into a lined container for upland disposal. The barge deck was not washed or sprayed down. The deck was swept to remove any loose material. Filter fabric and hay bales used to line the sideboards and scuppers around the perimeter of the deck line were also disposed of into a lined container for upland disposal.

2.7. BACKFILLING OPERATIONS

After all of the dredging was complete and the elevations were confirmed by the post-dredge survey, backfilling operations were allowed to begin. The modified backfill plan per RCO No. 001 is shown on Figure 5. Base backfill, habitat mix, and contingency cover sand and armor were obtained from the Glacier Northwest, Inc. quarry located in Dupont, Washington, and transported to the site by flat-deck haul barges. The armor rock was obtained by Glacier Northwest, Inc. from Texada Island, British Columbia.

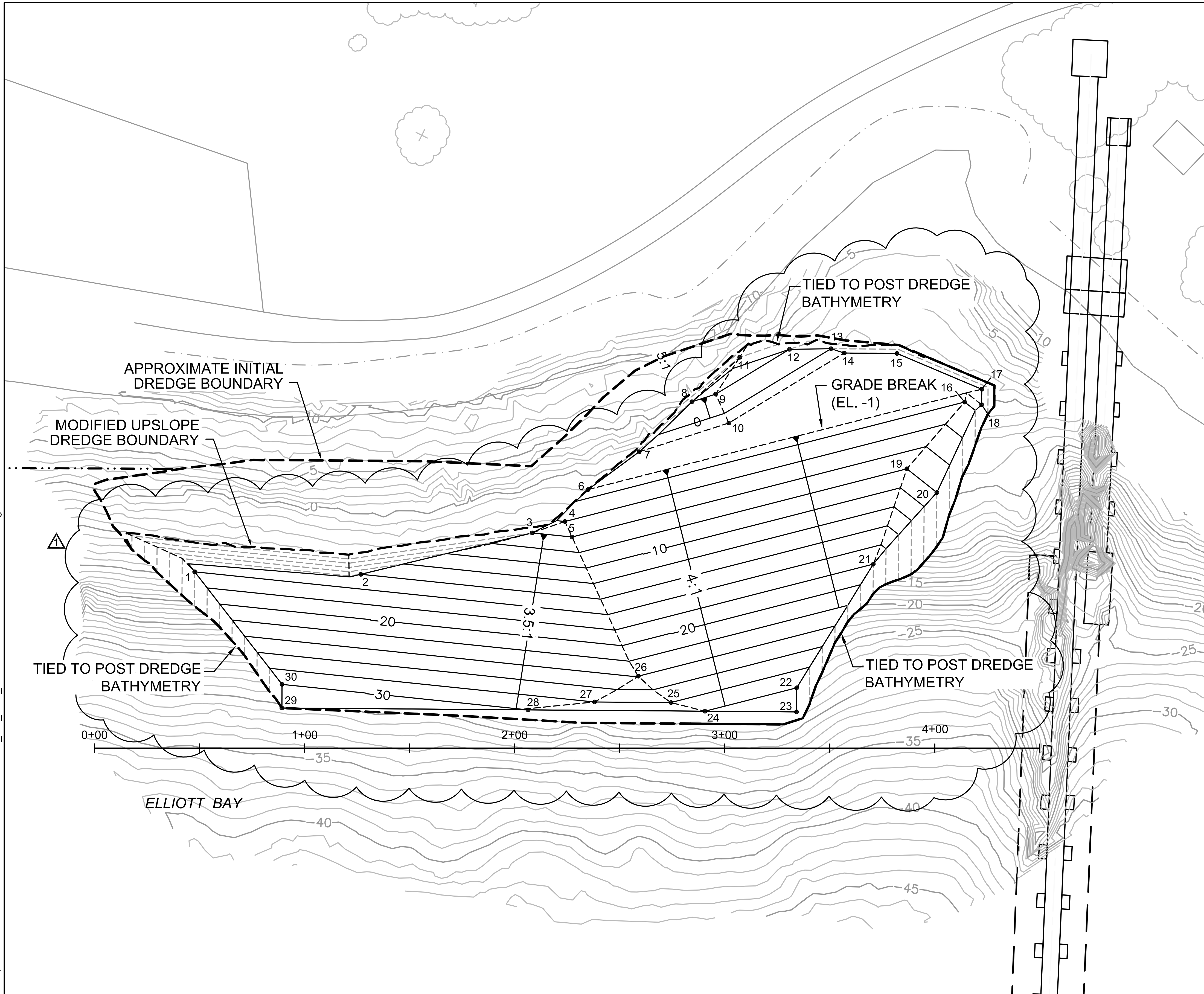
The contractor attempted to use beneficial reuse material from the Duwamish turning basin maintenance dredging, which was concurrently in construction. The maintenance dredging material that met the percent fines content requirement (less than 10 percent) in the Technical Specifications had already been dredged a few days before it could have been transferred to the Contractor to be used in the backfilling operations at the Denny Way site.

On January 16, 2008, the contractor attempted to load the "pocket barge" *S. Helens* with base backfill sand. The pocket barge had multiple controllable hoppers to deliver the backfill material capable of delivering a large volume of backfill material at once. The pocket barge was not able to contain the sand in the hoppers and approximately 1,000 cy of sand was lost through the hoppers into the surrounding waters at the loading facility. The pocket barge *S. Helens* was unloaded and was not used for the remainder of the project. All backfill materials were placed using the derrick *Pam Tay* with an ACC-built "skip box." The skip box was a rectangular structure with a 6-cy capacity measuring 12 feet by 6 feet by 2 feet with controllable bottom doors that could be partially opened for a controlled release of material, or fully opened to allow larger aggregate to pass through. A front-end loader operated on each backfill material barge and loaded material directly into the skip box. A front-end loader could load the skip box at an approximate rate of 6 cy in 30 seconds. King County performed water quality monitoring throughout backfilling operations and the results are located in Section 3.1.1.2.

Backfill material was generally released at mid-water column depth and placed in 2-foot lifts working from downslope to upslope. The contractor ordered material continually as it was needed based on the contractor's progress surveys. The procedure of placing backfill materials, surveying, and reviewing continued until the entire site was backfilled.

The post-backfill confirmatory survey (see Section 4.0) showed minor low spots. These low spots were corrected by placing additional backfill to grade, and an additional contractor survey was performed and accepted. The contractor placed habitat mix over the base backfill layer, which was confirmed by a post-backfill survey (see Section 4.0) that was also reviewed and accepted. Rock armor was placed on the upslope area to approximate pre-project armoring conditions after the habitat mix layer was complete.

All dredging results in the resuspension of particulate material (USACE 2008) and the backfill design required the evaluation for the need of a contingency cover layer in areas adjacent to and outside the dredge. Post-dredge sampling showed that there was dredge residual outside of the dredge boundary at the closest monitoring station and showed the need for the placement of contingency cover material. A 6-inch contingency cover layer of sand was placed outside the dredge boundary as shown in Figure 6.



LEGEND

- —20— TARGET BASE BACKFILL MATERIAL CONTOURS
- APPROXIMATE BACKFILL BOUNDARY
- —10— EXISTING BATHYMETRIC CONTOURS AND ELEVATION IN FEET (2-FOOT INTERVAL)
- APPROXIMATE POST-DREDGE CONTOUR
- 6 BACKFILL COORDINATE
- BACKFILL BOUNDARY

NUMBER	EASTING	NORTHING
1	1263421.59	229520.92
2	1263475.27	229462.84
3	1263545.77	229417.34
4	1263560.44	229409.78
5	1263557.43	229402.23
6	1263579.08	229412.26
7	1263608.82	229407.03
8	1263643.43	229405.25
9	1263653.83	229399.58
10	1263648.20	229385.56
11	1263674.43	229403.36
12	1263693.50	229388.83
13	1263707.35	229374.72
14	1263710.17	229368.78
15	1263727.39	229350.41
16	1263732.83	229311.14
17	1263742.84	229309.43
18	1263737.46	229304.38
19	1263690.83	229309.14
20	1263692.50	229291.02
21	1263646.95	229289.44
22	1263579.19	229275.27
23	1263570.81	229267.42
24	1263540.99	229299.23
25	1263532.82	229313.79
26	1263531.19	229333.70
27	1263507.92	229340.36
28	1263483.39	229360.68
29	1263403.26	229446.17
30	1263411.46	229453.86

NOTES:

1. FIGURE PREPARED FROM DRAWING PROVIDED BY BLACK & VEATCH CORPORATION ENTITLED "HABITAT RESTORATION PLAN", DATED NOVEMBER 1999.
2. BATHYMETRY PREPARED FROM SURVEY PROVIDED BY eTRAC DATED OCTOBER 30, 2007.
3. HORIZONTAL DATUM: SP NAD 83 WA N
4. VERTICAL DATUM: MLLW

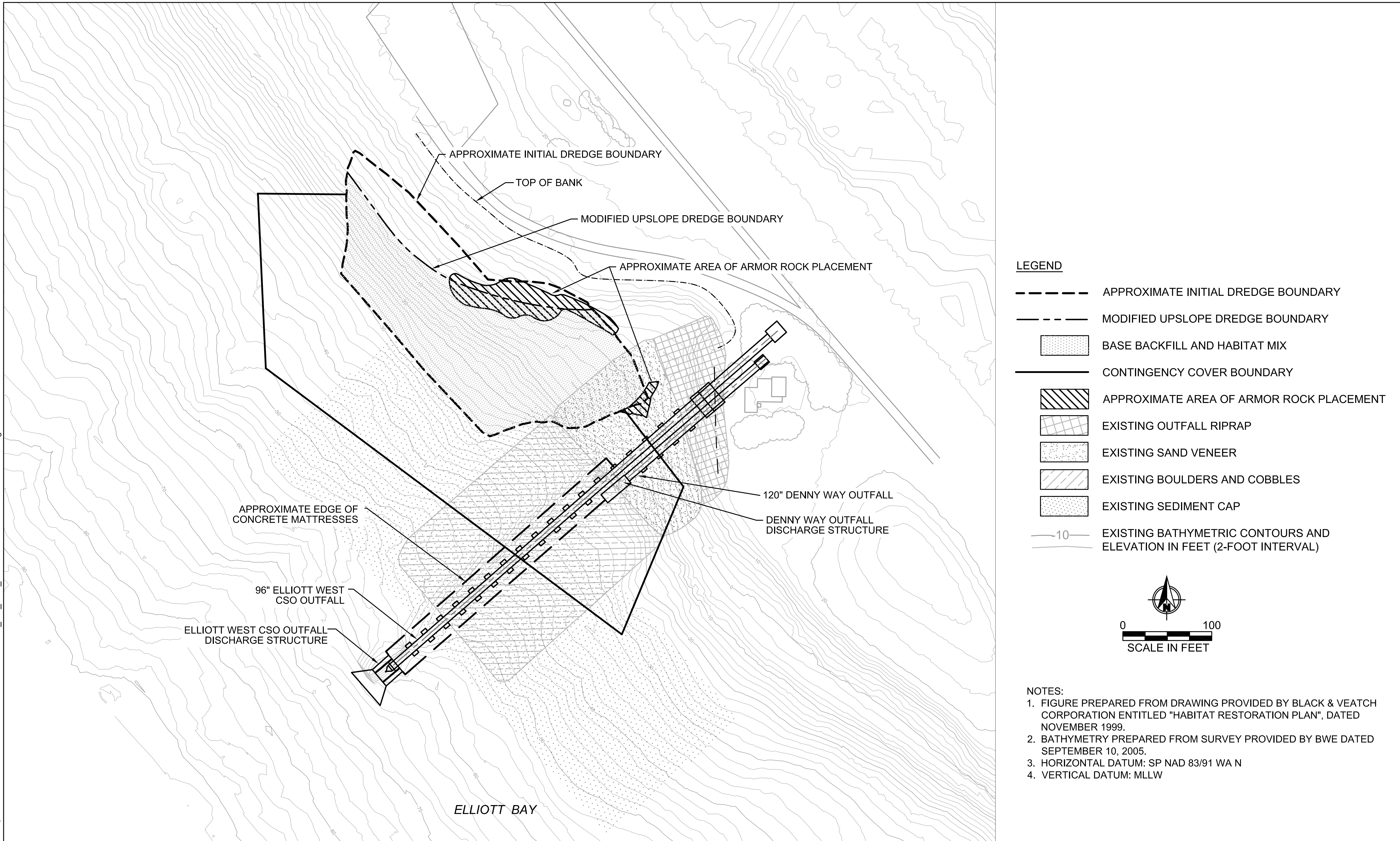
⚠ MODIFICATION TO DREDGE DESIGN

0 50
SCALE IN FEET

Jun 23, 2008 11:49am cdavidson K:\Jobs\020067-KING_CO_SED_MANAG\020067011\02006701-118.dwg FIG 5

ANCHOR ENVIRONMENTAL, L.L.C.

Figure 5
Target Base Backfill Plan
Denny Way CSO Nearshore Interim Sediment Cleanup Project



NOTES:
1. FIGURE PREPARED FROM DRAWING PROVIDED BY BLACK & VEATCH CORPORATION ENTITLED "HABITAT RESTORATION PLAN", DATED NOVEMBER 1999.
2. BATHYMETRY PREPARED FROM SURVEY PROVIDED BY BWE DATED SEPTEMBER 10, 2005.
3. HORIZONTAL DATUM: SP NAD 83/91 WA N
4. VERTICAL DATUM: MLLW

Jun 30, 2008 8:34am cdavidson K:\Jobs\020067-KING_CO_SED_MANAG\02006701\02006701-124.dwg FIG 6

ANCHOR ENVIRONMENTAL, L.L.C.

Figure 6
Armor Rock and Contingency Cover Placement Areas
Denny Way CSO Nearshore Interim Sediment Cleanup Project

Backfill material placement occurred over 26 days with approximately 19,460 cy of material placed. The average production rate of all material placed was approximately 748 cy per day. The contractor encountered some equipment and mechanical problems during backfilling that slowed the production rate. The DGPS system for determining horizontal positioning of the clamshell bucket relative to the dredge plan did not function correctly at various times during backfilling. The front-end loader used to load the skip box needed maintenance on land, halting the backfilling. The skip box doors were damaged during the placement of the armor rock and had to be fixed before proceeding with armor rock placement. Foul weather days also contributed to slowed production rates during backfill activities. Operational controls (cycle time) to limit the effects of resuspension and pausing work to allow turbidity to decrease also limited the production rate. Several turbidity exceedances occurred during backfilling, and the contractor stopped backfilling work for short periods of time to re-position work barges to allow the turbidity readings to decrease (see Section 3.0). During backfilling, unavailability of backfill material accounted for 3.5 days of lost time; however, at most stages of backfill activities materials were readily available from the quarry. The production rate was not restrained by the time required to review and approve confirmatory surveys, which typically took less than 24 hours to complete.

Base backfill material placement occurred over 12 10- to 15-hour days, with approximately 11,886 cy placed. The contractor spent approximately 63 hours placing the 11,886 cy of base backfill material. This time only includes actual backfilling time, and equates to a gross production rate of 189 cy per hour. The total production time to place the 11,886 cy was 138 hours. This time includes backfilling, equipment movement, maintenance, downtime, and other non-productive time. Therefore, the net production rate was 86 cy per hour.

Habitat mix placement occurred over 8.5 10-hour days, with approximately 4,821 cy placed. The contractor spent approximately 30.5 hours placing the 4,821 cy of habitat mix material. This time only includes actual backfilling time, and equates to a gross production rate of 158 cy per hour. The total production time to place the 4,821 cy was 85 hours. This time includes backfilling, equipment movement, maintenance, downtime, and other non-productive time. Therefore, the net production rate was 56 cy per hour.

Armor rock placement occurred over 3 10-hour days, with approximately 758 tons placed. The contractor spent approximately 7 hours placing the 758 tons of armor rock material. This time only includes actual backfilling time, and equates to a gross production rate of 108 tons per hour. The total production time to place the 758 tons was 30 hours. This time includes backfilling, equipment movement, maintenance, downtime, and other non-productive time. Therefore, the net production rate was 25 tons per hour.

Contingency cover material placement occurred over 2 12-hour days and 1 10-hour day, with approximately 1,540 cy placed. The contractor spent approximately 19 hours placing the 1,540 cy of contingency cover material. This time only includes actual backfilling time, and equates to a gross production rate of 81 cy per hour. The total production time to place the 1,540 cy was 34 hours. This time includes backfilling, equipment movement, maintenance, downtime, and other non-productive time. Therefore, the net production rate was 45 cy per hour.

Backfilling activities occurred from January 17 to February 25, 2008. A permit extension was issued to work beyond the beginning of the fish window closure from February 16 to March 1. The contractor used only 5 in-water work days after February 15 to complete remaining backfilling activities.

2.7.1 Lessons Learned

The opportunity to beneficially reuse acceptable dredge material may have been achieved with closer coordination of the projects. Such coordination will likely require project management coordination during the construction phase as the contractors are too busy with their individual projects.

Water quality exceedances during backfilling may have been minimized by further increasing the cycle time, or releasing the backfill material near the mudline, which would have likely impacted the contractor's schedule. However, based on past project experience with placing sand from an upland source into the aquatic environment, turbidity is a frequent occurrence during this type of operation.

Similar to during dredging, contractor progress surveys were not submitted in a timely manner and may have contributed to high spots near the toe of the dredge boundary.

Project personnel decided to place contingency cover material after post-dredge sampling at perimeter stations had occurred but before post-backfill confirmatory sampling had taken place due to timing constraints with the fish window. This decision was contrary to the Technical Specifications, which stated that the contingency cover material would be based on post-backfill confirmatory sampling that included a 7-day standby time as a bid item, during which time the confirmatory samples would be analyzed and reviewed. It may benefit future projects to base decisions to place contingency cover material on post-dredge sampling, or build in such flexibility in the Technical Specifications.

3.0 Compliance Monitoring

The MTCA requires three types of compliance monitoring to be performed in order to confirm the adequacy of a remedial action (WAC 173-340-410). These include protection monitoring, performance monitoring, and confirmational monitoring. The compliance monitoring performed during the Denny Way CSO Nearshore Interim Sediment Cleanup Project is discussed in this section. The King County Department of Natural Resources and Parks (KCDNRP) produced two sampling and analysis plans in September 2007, which describe the water quality monitoring activities and the sediment monitoring activities, and a third long-term sediment sampling and analysis plan was produced in March 2008. These three plans (KCDNRP 2007a, 2007b, and 2008) are included in Appendices F, G, and H, respectively, and should be consulted for the details of the sampling design and procedures used to collect the compliance monitoring samples.

3.1. PROTECTION MONITORING

Protection monitoring is performed to confirm that human health and the environment are adequately protected during construction of the cleanup action as described in the contractor's specific safety and health plan (WAC 173-340-410(a)). No deviations from the contractor's health and safety plan were reported or observed.

Water quality monitoring of Elliott Bay in the vicinity of the project site was required in the Ecology Agreed Order DE No. 5068. During construction, turbidity and dissolved oxygen (DO) had to be maintained within applicable water quality standards listed in WAC 173-201A at a point 300 feet from the location of dredging or backfill material release into Elliott Bay. Details of the water quality monitoring were included in the Agreed Order DE No. 5068 and in the *Dredging and Backfilling Operations Construction Water Quality Monitoring Plan* (KCDNRP 2007a). Additionally, water quality monitoring was required as part of the Biological Evaluation (Anchor 2007a).

3.1.1 Water Quality Monitoring

Water quality monitoring was performed in accordance with the approved *Dredging and Backfilling Operations Construction Water Quality Monitoring Plan* (KCDNRP 2007a). King County monitored water quality proximal to the construction site through the use of a monitoring buoy deployed approximately 300 feet northwest of the site, down-current of construction activities, in approximately 35 feet of water (referenced to MLLW). Previous studies have shown that the net current flow in the vicinity of the site is in a northwesterly direction, following the Seattle waterfront shoreline (Ebbesmeyer et al. 1998). Surface water in this part of Elliott Bay is influenced by discharges from the Duwamish River, which follow the net prevailing currents along the waterfront shoreline.

The instrument used for water quality monitoring on this project was the YSI 6600EDS multi-parameter sonde. A YSI 6600EDS sonde consists of a cylindrical pressureresistant body with a cable connection on one end and temperature, conductivity, pressure (depth), dissolved oxygen, and turbidity probes on the opposite end. The sonde was deployed at a depth of 1 meter below the surface, and the depth remained constant during tidal fluctuations. Figure 7 shows the location of the water quality monitoring buoy in relation to the site and construction area. Background water quality information for Elliott Bay was collected by a second water quality monitoring system located at the Seattle Aquarium, which allowed King County staff to compare real-time water quality data between the site and background Elliott Bay conditions. Figure 7 shows the relative location of the Denny Way and Seattle Aquarium monitoring stations.

Both water quality monitoring systems included a real-time data acquisition system (DAS) consisting of a multi-parameter data sonde and telemetry system that allowed for data collection, storage, and review via the internet. Data collection occurred every 15 minutes with hourly data transferral via the DAS to a YSI Econet web interface. The data were transmitted to a secure server and posted directly to a customizable web site. The data could be downloaded in a number of ways, including automatic or customizable graphs, HTML, or CSV formats.

One week prior to the start of construction, throughout the first 14 days of construction, and when the *in situ* monitoring system was not operational, King County collected manual daily water samples for laboratory analysis of both turbidity and DO from a location in the proximity of the water quality monitoring systems. Manual samples were collected and submitted to Ecology instead of data collected from the water quality monitoring systems during the first 14 days of construction because the water quality monitoring systems needed continuing calibration and encountered technical difficulties. Manual water sample collection and analysis served as a calibration check for the *in situ* monitoring systems and as an alternative data-collection method when the *in situ* systems were not functioning correctly.

It was anticipated that the *in situ* monitoring sensors would perform according to the manufacturer's specifications. As such, the field quality control (QC) samples were reduced to weekly collection, as a calibration check, following the first 14 days of construction for the remainder of the monitoring period.

Weekly water quality data reports were prepared and submitted to Ecology. The weekly water quality reports included a summary of the continuous *in situ* data, along with results of QC sample analysis for turbidity and DO, and a description of how the QC results impacted the *in situ* data.

As discussed in the *Dredging and Backfilling Operations Construction Water Quality Monitoring Plan* (KCDNRP 2007a), a turbidity exceedance was recorded if the average turbidity at the site buoy measured over a 1-hour time period was more than 5 Nephelometric Turbidity Units (NTU) higher than the average turbidity measured over the same 1-hour period at the background (Seattle Aquarium) monitoring station when the background turbidity was 50 NTU or less, or if the average turbidity at the site buoy measured over a 1-hour time period increased more than 10 percent when background turbidity was greater than 50 NTU. Similarly, DO was averaged hourly at the site buoy and compared to applicable DO standards for Elliott Bay.

Jun 23, 2008 11:58am cdavidson K:\Jobs\020067-KING_CO_SED_MANAG\02006701\02006701-123.dwg FIG 7

ANCHOR ENVIRONMENTAL, L.L.C.

Figure 7
Water Quality Monitoring Buoy and Seattle Aquarium Reference Station
Denny Way CSO Nearshore Interim Sediment Cleanup Project

3.1.1.1 Results of Water Quality Monitoring During Dredging

Appendix D of this report contains the 1-hour average water quality monitoring turbidity data collected by the site water quality monitoring buoy, and Appendix E contains the complete water quality monitoring dataset generated from the on-site buoy. Dredging activities were conducted between November 30, 2007, and January 12, 2008. Only one water quality exceedance was recorded during the dredging activities, which occurred on January 8, 2008. The date, time, tidal condition associated with the water quality exceedance, and turbidity value above background (site buoy value minus background value) are shown in Table 1.

Table 1
Water Quality Monitoring Exceedance During Dredging

Date	Time	Tide	Site Turbidity Measurement Referenced to Background (NTU)
Tuesday, January 8, 2008	4:00pm	ebb	5.7

The turbidity exceedance occurred during the 1-hour average for 4:00 p.m., but the contractor had already voluntarily stopped dredging at approximately 3:45 p.m. due to elevated turbidity readings before the exceedance occurred. From January 3 to January 8, 2008, increases in turbidity were observed that were directly related to the use of the barge-mounted excavator (deployed under change order to remove armor rock), which typically lost up to half of the mixed armor and sediment material from each bite into the water column or near the water surface. The excavator bucket was ineffective at selecting concrete debris and resulted in a mix of water and sediment and minimal amounts of concrete with each bucket brought to the surface. Heavy losses of material from the excavator bucket occurred during the handling period as it was raised over the fence on the material barge to reach the flat deck area of the hull. When turbidity measurement increases were observed, the contractor was notified immediately and the contractor responded with a change in best management practices (BMPs) whenever possible. In most cases, the operational response was to stop the operation for a short period of time (e.g., 15 to 30 minutes) or stop working for the day. Typically, increases in turbidity measurements were correlated to the ebb tide, and the contractor attempted to use the excavator during the flood tide to contain the turbidity plume near the dredge platform. Turbidity measurements during the use of the clamshell bucket were relatively low, and no exceedances were recorded during its use. There were no impacts to DO observed such that there were no noticeable decreases in DO during dredging activities.

3.1.1.2 Results of Water Quality Monitoring During Backfilling

Appendix D of this report contains the 1-hour average water quality monitoring turbidity data collected by the site water quality monitoring buoy, and Appendix E contains the complete water quality monitoring dataset generated from the on-site buoy. Backfilling activities were conducted between January 17 and February 23, 2008. Twenty turbidity water quality exceedances were recorded during the backfilling activities. The dates, times, tidal condition associated with the water quality exceedances, and turbidity exceedance values above background (site buoy value minus background value) are shown in Table 2.

Table 2
Water Quality Monitoring Exceedances During Backfilling

Date	Time	Tide	Site Turbidity Measurement Referenced to Background (NTU)
January 17, 2008	12:00pm	ebb	7.15
January 17, 2008	1:00pm	ebb	5.27
January 17, 2008	3:00pm	ebb	5.78
January 22, 2008	8:00am	ebb	8.18
January 22, 2008	9:00am	ebb	9.68
January 24, 2008	11:00am	flood	6.95
January 24, 2008	12:00pm	flood	14.28
January 24, 2008	3:00pm	flood	5.05
January 28, 2008	10:00am	ebb	7.85
January 28, 2008	1:00pm	ebb	5.08
January 28, 2008	2:00pm	ebb	9.22
January 29, 2008	10:00am	ebb	12.45
January 29, 2008	11:00am	ebb	6.01
January 29, 2008	1:00pm	ebb	6.75
January 29, 2008	2:00pm	ebb	16.82
January 29, 2008	7:00pm	ebb	5.32
February 5, 2008	11:00am	flood	5.67
February 7, 2008	6:00am	ebb	11.78
February 7, 2008	7:00am	ebb	10.63
February 13, 2008	7:00am	ebb	6.4

Water quality exceedances during backfilling activities were associated with the spread of clean backfill material beyond the dredge boundary. Fine-grained particles in the backfill materials contributed to the increased turbidity measurements during backfill material placement and continued to impact water quality throughout placement of backfill until habitat mix material placement had been completed. Water quality exceedances during backfilling typically occurred during the ebb tide as shown in Table 2. It was observed in the field that turbidity generated during backfill placement appeared to be contained near the dredge equipment platform during the flood tide and that turbidity plumes moved toward the site buoy during the ebb tide. The contractor typically tried to place backfill material during the flood tide to minimize turbidity exceedances during the work shift. When turbidity increases were noted and exceedances occurred, the contractor would stop the placement of backfill for a short period of time (e.g., 15 to 30 minutes) to allow the turbidity to decrease. Fourteen of the water quality exceedances occurred during placement of base backfill material and four exceedances occurred during placement of habitat mix. The turbidity exceedance for 7:00pm on January 29, 2008 occurred approximately 3 hours after backfilling activities had stopped for the day and rough weather may have contributed to the resuspension of backfill material such that turbidity was generated. Two turbidity exceedances that occurred on February 7, 2008 were measured before the work crew arrived at the site and no work was being performed.

3.1.1.3 Lessons Learned

Water quality monitoring with the real-time systems was viewed by project personnel as a success during its use at the site. Once correctly calibrated and functioning normally, the systems were effective at producing frequent water quality data that were available to all project personnel.

Water quality monitoring performed manually typically results in one to two samples taken during construction activities and targets areas where plumes exist in the water column. The disadvantage of the manual sampling approach is that it results in a much smaller water quality dataset when compared to the use of an on-site water quality station that provides continual monitoring. The advantage of continual monitoring is that it captures real-time water quality information, which is useful in determining impacts to water quality at any time during construction. A disadvantage of the continual monitoring approach is that it cannot target multi-directional plumes that cannot be tracked by the stationary buoy.

The use of a water quality monitoring buoy may have other deficiencies that should be taken into account before deployment at a different site. A turbidity plume may not have accurately been captured since the buoy was only collecting data at 1 meter below the water surface and turbidity plumes may affect the water column at lower depths. Unique site conditions may have more complex current patterns where a single fixed buoy may not adequately collect representative water quality data because the buoy is not accurately capturing the plume of turbidity downstream of the work. Hydroacoustic surveys could be used at the site during the initial startup of construction activities and could provide information to enhance the placement of a site buoy, and the use of upper, middle, and bottom water quality sondes would capture a more complete dataset representative of the entire water column. The use of multiple buoys on a site would generate more data, which could increase the possibility of capturing water quality exceedances, and an appropriate strategy (e.g., up-front agency education and planning) would need to be in place so that work could be performed efficiently; however, multiple buoys may still not accurately characterize turbidity plumes if the movement of the plumes is not fully understood at a given site. Additional buoys may also hinder movement of construction by limiting movement of equipment and may also obstruct vessel navigation.

Environmental effects at the site including tides, wind, and nearby large vessel activity also influenced the water quality monitoring measurements at the site buoy and may not have been accurately accounted for due to the stationary position of the site buoy. An example of these environmental influences during backfilling activities occurred when turbidity exceedances were observed during ebb tide, which periodically occurred in the afternoon. In this example, turbidity may have been contained near the derrick platform during flood tide (during the morning before the ebb tide occurred) or it is possible that turbidity may have been moving in the opposite direction (upstream direction) away from the buoy until the tide changed to ebb tide. But ultimately, with the net currents flowing toward the site buoy, turbidity exceedances were noted at the site buoy.

The water quality data collected at the background monitoring system located at the Seattle Aquarium may have been influenced locally by the Duwamish River or nearby stormwater discharges, and may not have been an accurate indicator of background conditions. For example, at various times during the project, the background turbidity measurements were higher than the site turbidity measurements, indicating that a background buoy placed at distance from the site did not always characterize project-specific background water quality conditions.

3.1.1.4 Real-Time Monitoring

The near-real-time remote data acquisition system allowed project personnel to monitor water quality constantly during construction activities, and detect almost immediately if construction activities had an impact on turbidity or DO concentrations. Ecology valued the real-time monitoring data and viewed it as a success for the project.

3.2. PERFORMANCE MONITORING

Performance monitoring is conducted to confirm that the cleanup action has attained cleanup standards or other performance standards (WAC 173-340-410 (b)).

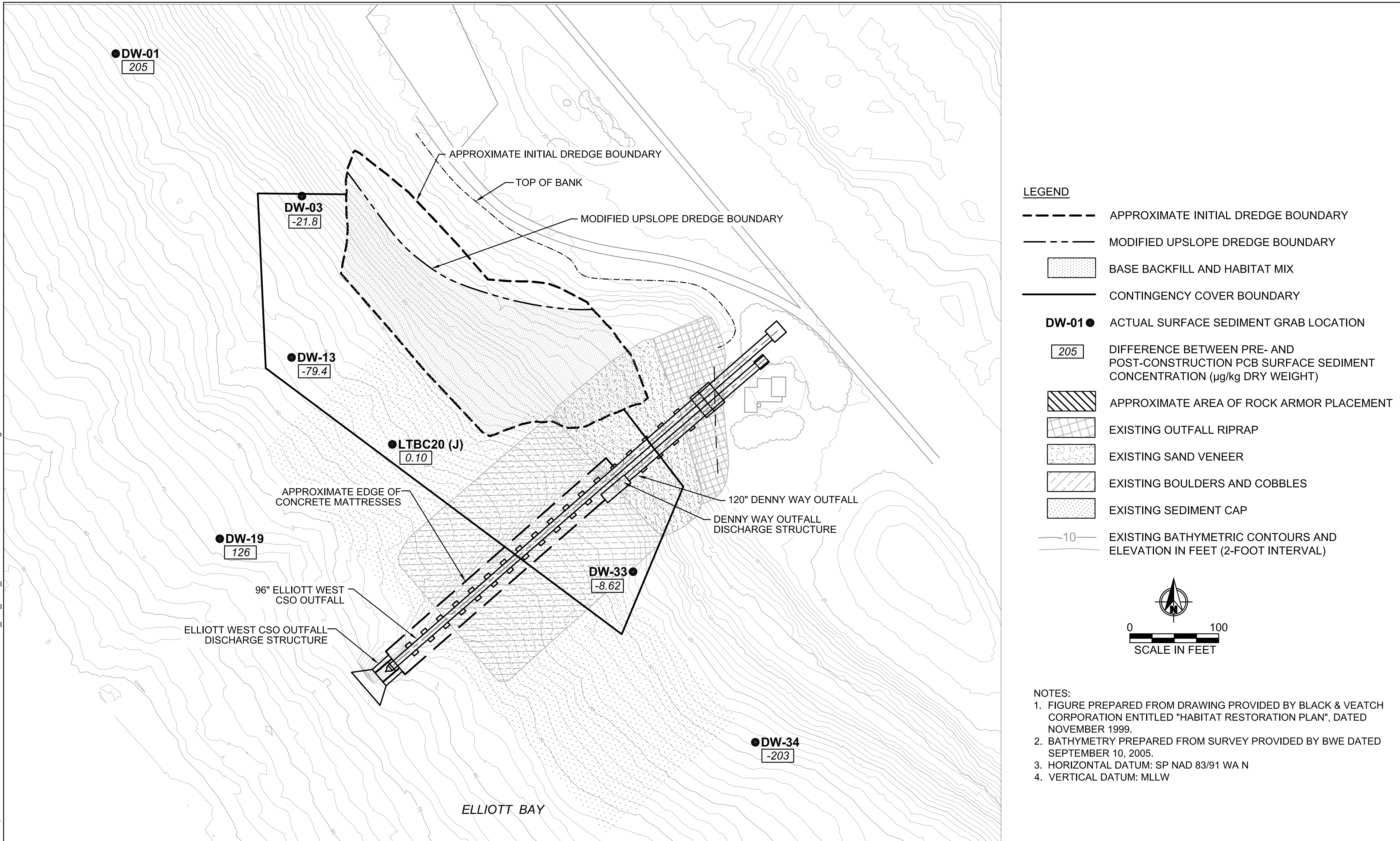
3.2.1 Post-Dredge, Post-Base Backfill, and Post-Habitat Mix Surveys

Throughout the dredging and backfilling operation, bottom surveys performed by the contractor were submitted to King County's project engineer and reviewed for compliance with the Contract Drawings. When all high spots identified by the contractor's surveys had been removed, a post-dredge survey was conducted by eTrac

Engineering, L.L.C. (eTrac) to independently confirm the dredging results. The post-dredge survey showed that the contractor removed sediments to the required elevations shown in the Contract Drawings and as described in the Technical Specifications. Similarly, the contractor's surveys were used to confirm that each backfill material thickness was sufficient before eTrac conducted the post-base backfill and post-habitat mix surveys. These surveys showed that the base backfill and habitat mix layers were placed in accordance with the Contract Drawings and Technical Specifications. Surveys are discussed further in Section 4.0.

3.2.2 Sediment Sampling

When the *Dredging and Backfilling Operations Sediment Monitoring Sampling and Analysis Plan* (KCDNRP 2007b; Appendix G) was prepared for the project, Ecology required sediment sampling beyond the site boundary to document any changes in chemical concentrations of surface sediments due to dredge material moving beyond the site boundary. Ecology also required post-dredge sampling within the dredge boundary in areas where backfill would be less than 3 feet thick to characterize post-dredge surface sediment quality conditions after dredging activities were completed and before backfilling activities were initiated. A total of seven monitoring stations were established beyond the site boundary and sampled before and after the project was implemented to document potential changes over time. A total of five stations were established within the dredge prism to evaluate the sediment at the post-dredge surface. Figure 8 shows that stations DW-01, DW-03, DW-13, DW-19, DW-33, DW-34, and LTBC20 (J) were spaced upstream, downstream, and offshore of the dredge site and ranged from 50 to 400 feet from the boundary of the dredge prism, as requested by Ecology. Figure 9 shows the five grab stations (DWPD-01, DWPD-02, DWPD-03, DWPD-04, and DWPD-05) as requested by Ecology and one core station (DW105) located within the dredge footprint. At stations where samples were mostly gravel, multiple sediment grabs were necessary to obtain an adequate sample volume for chemistry analysis. To verify reproducibility of the grab samples, a field replicate was obtained at one station (LTBC20 (J)) before construction. No field replicate was collected at the sampling event following construction.

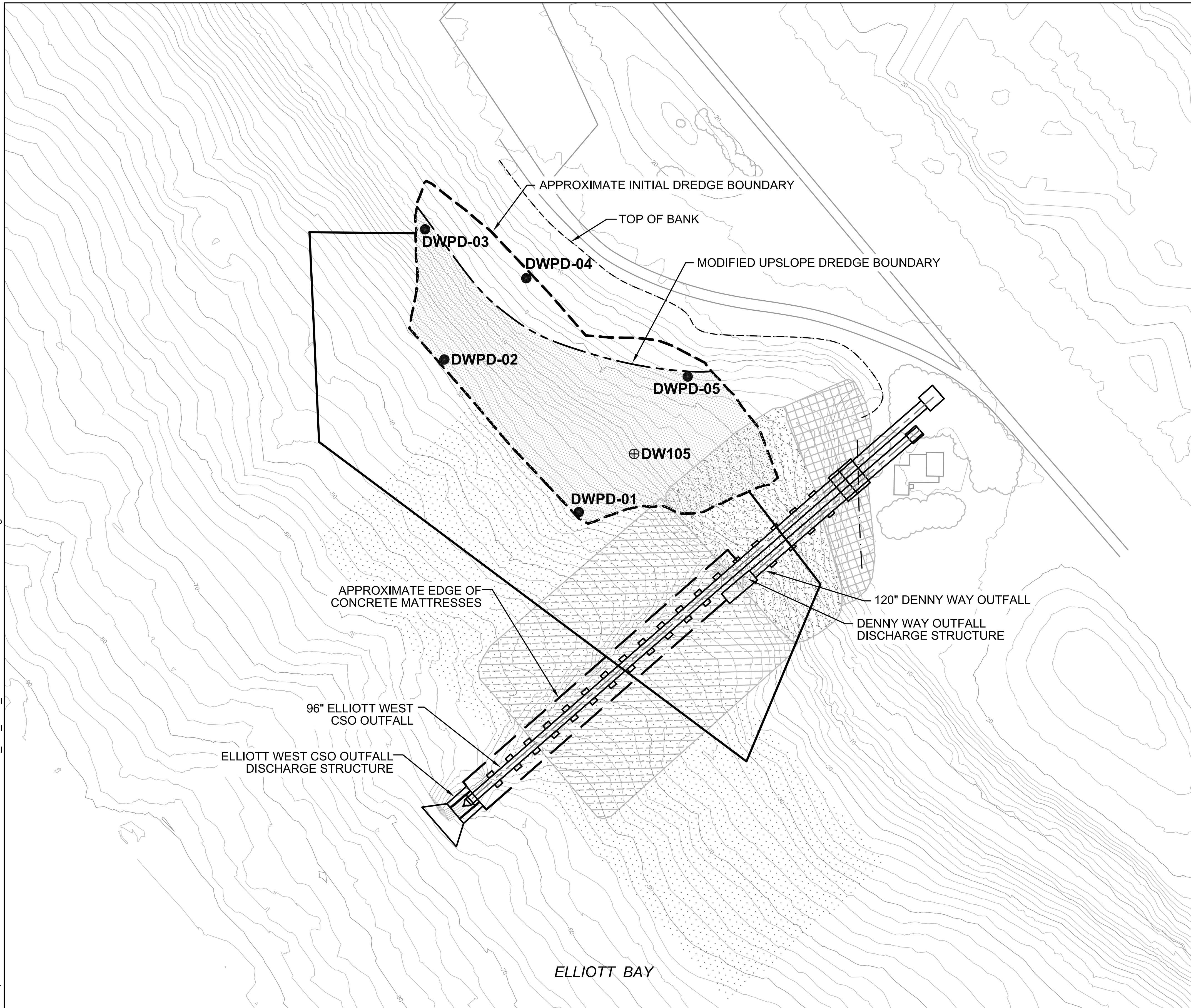


NOTES:
1. FIGURE PREPARED FROM DRAWING PROVIDED BY BLACK & VEATCH CORPORATION ENTITLED "HABITAT RESTORATION PLAN", DATED NOVEMBER 1999.
2. BATHYMETRY PREPARED FROM SURVEY PROVIDED BY BWE DATED SEPTEMBER 10, 2005.
3. HORIZONTAL DATUM: SP NAD 83/91 WA N
4. VERTICAL DATUM: MLLW

Jun 30, 2008 8:35am cdavidson K:\Jobs\020067-KING_CO_SED_MANAG\02006701\02006701-121.dwg FIG 8

ANCHOR ENVIRONMENTAL, L.L.C.

Figure 8
Post-Construction Changes in PCB Dry Weight Concentrations at 7 Stations Beyond Site Boundary
Denny Way CSO Nearshore Interim Sediment Cleanup Project



LEGEND

APPROXIMATE INITIAL DREDGE BOUNDARY
MODIFIED UPSLOPE DREDGE BOUNDARY
BASE BACKFILL AND HABITAT MIX
CONTINGENCY COVER BOUNDARY
DWPD-01 ● ACTUAL SURFACE SEDIMENT GRAB LOCATION
DW105 ⊕ ACTUAL SUBSURFACE SEDIMENT CORE LOCATION
EXISTING OUTFALL RIPRAP
EXISTING SAND VENEER
EXISTING BOULDERS AND COBBLES
EXISTING SEDIMENT CAP
10 EXISTING BATHYMETRIC CONTOURS AND ELEVATION IN FEET (2-FOOT INTERVAL)

0 100
SCALE IN FEET

NOTES:
1. FIGURE PREPARED FROM DRAWING PROVIDED BY BLACK & VEATCH CORPORATION ENTITLED "HABITAT RESTORATION PLAN", DATED NOVEMBER 1999.
2. BATHYMETRY PREPARED FROM SURVEY PROVIDED BY BWE DATED SEPTEMBER 10, 2005.
3. HORIZONTAL DATUM: SP NAD 83/91 WA N
4. VERTICAL DATUM: MLLW

Jun 30, 2008 11:20am cdavidson K:\Jobs\020067-KING_CO_SED_MANAG\02006701\02006701-126.dwg FIG 9

ANCHOR ENVIRONMENTAL, L.L.C.

Figure 9
Post-Dredge Surface and Subsurface Sample Locations within Site Boundary
Denny Way CSO Nearshore Interim Sediment Cleanup Project

3.2.2.1 Sediment Analyses

All sediment samples collected beyond the site boundary for before and after comparisons, and sediment samples collected within the dredge prism at the dredge surface were submitted to the King County Environmental Laboratory for analysis of standard SMS sediment characterization parameters (PCBs, base/neutral/acid extractable semi-volatiles [BNAs], mercury, SMS metals, and the sediment conventional parameters of total organic carbon [TOC], total solids, and particle size distribution [PSD]). The analytical methods used for various parameters are listed in Appendices G and H. All analyses were performed under QA1 guidance (Ecology 1989) per the methods described in the *Dredging and Backfilling Operations Sediment Monitoring Sampling and Analysis Plan*(KCDNRP 2007b) for the pre-construction and post-dredge (inside prism) sampling events, and the *Denny Way CSO and Elliott West CSO Treatment Facility, Post Operation Sediment Monitoring, Year 3, Denny Way CSO Areas A and B Nearshore Sediment Remediation Project Post-Construction Sediment Monitoring, Areas C, D, and E Monitoring Sampling and Analysis Plan* (KCDNRP 2008) for the post-construction sampling event (See section 6.0). The resulting data underwent QA1 review, presented in Appendix I. Results of the analyses are presented in Tables 3 to 5 and are discussed below.

Table 3
Chemicals that Exceeded SMS at Seven Stations Beyond the Site Boundary
Before and After Construction

Stations	PCBs		BEHP		BBP		Mercury	
	Before	After	Before	After	Before	After	Before	After
DW-01	SQS	SQS	SQS	NE	SQS	NE	CSL	CSL
DW-03	NE	NE*	NE	NE**	NE	NE***	NE	NE
DW-13	NE	NE*	NE	NE**	SQS	NE***	NE	NE
DW-19	SQS	SQS	SQS	NE	NE	NE	CSL	SQS
DW-33	NE	NE*	NE	NE**	NE	NE***	NE	NE
DW-34	SQS	SQS	CSL	NE	SQS	NE	SQS	NE
LTBC20 (J)	NE	NE*	NE	NE**	SQS	NE***	NE	NE
LTBC20 (J) Rep	NE	NS	SQS	NS	NE	NS	NE	NS
Stations>SQS	3>SQS	3>SQS	3>SQS	--	4>SQS	--	1>SQS	1>SQS
Stations>CSL	--	--	1>CSL	--	--	--	2>CSL	1>CSL

BBP = butylbenzylphthalate
BEHP = bis(2 ethylhexyl)phthalate
CSL = Cleanup Screening Level
NE = No Exceedance
NS = Not Sampled
PCB = polychlorinated biphenyl
SQS = Sediment Quality Standards
* Low total organic carbon (TOC) for this sample; NE based on comparing dry weight concentrations to lowest apparent effects threshold (LAET) and second lowest apparent effects threshold (2LAET) criteria (130 and 1,000 micrograms per kilogram [µg/kg], respectively) for total PCBs (Sediment Management Standards [SMS])
** Low TOC for this sample; NE based on comparing dry weight concentrations to LAET and 2LAET criteria (1,300 and 1,900 µg/kg, respectively) for BEHP
*** Low TOC for this sample; NE based on comparing dry weight concentrations to LAET and 2LAET criteria (63 and 900 µg/kg, respectively) for BBP

Table 4
Changes in PCB Dry Weight and SMS Values at Seven Stations Beyond the Site Boundary After Construction

Stations	PCB Concentration (µg/kg dry weight) #				PCB Concentration (mg/kg OC)			
	Before	After	Increase	Decrease	Before	After	Increase	Decrease
DW-01	504	709	205	--	24.3*	35.2*	10.9	--
DW-19	286	412	126	--	15.0*	14.7*	--	0.3
LTBC20 (J)	34.0	34.1	0.1	--	3.40	low TOC	--	--
LTBC20 (J) Rep	60.9	NS	N/AV	N/AV	3.81	NS	N/AV	N/AV
DW-33	9.82	<1.2	--	8.62	0.89	low TOC	--	--
DW-03	35.2	13.4	--	21.8	1.46	low TOC	--	--
DW-13	80.5	<1.1	--	79.4	4.74	low TOC	--	--
DW-34	585	382	--	203	39.0*	15.9*	--	23.1

Stations	Total Solids (percent dry weight)				TOC (percent dry weight)			
	Before	After	Increase	Decrease	Before	After	Increase	Decrease
DW-01	52.7	53.2	0.5	--	2.07	2.01	--	0.06
DW-19	53.3	58	4.7	--	1.93	1.95	0.02	--
LTBC20 (J)	69.3	79	9.7	--	0.95	0.18	--	0.77
LTBC20 (J) Rep	63.2	NS	N/AV	N/AV	1.61	NS	N/AV	N/AV
DW-33	90.0	86.3	--	3.7	1.11	<0.05	--	1.06
DW-03	75.9	79.2	3.3	--	2.42	0.10	--	2.32
DW-13	59.6	92.5	32.9	--	1.68	<0.05	--	1.63
DW-34	66.6	60.2	--	6.4	1.45	2.38	0.93	--

= Values rounded to three significant figures
* = Value exceeds Sediment Quality Standards (SQS)
µg/kg = microgram per kilogram
mg/kg = milligrams per kilogram
NS = Not Sampled
N/AV = Not Available
OC = organic carbon-normalized
PCB = polychlorinated biphenyl
TOC = total organic carbon

Table 5
Chemicals that Exceeded SMS at Six Stations at the Post-dredge Surface

Stations	PCBs	BEHP	BBP	Mercury	Cadmium	Lead	Silver	Zinc	Acenap-hthene	1,4-Dichloro-benzene	Fluorene	Phen-anthrene	Anthra-cene
DWPD-01	NE	NE	NE	SQS	NE	NE	NE	NE	NE	NE	NE	NE	NE
DWPD-02*	SQS	NE	NE	CSL	CSL	CSL	CSL	CSL	NE	NE	CSL	SQS	CSL
DWPD-03	SQS	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
DWPD-04	SQS	CSL	NE	CSL	NE	NE	NE	NE	NE	SQS	NE	NE	NE
DWPD-05*	SQS	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
DW105 (0 to 1 foot)	SQS	CSL	NE	CSL	NE	NE	CSL	NE	NE	CSL	NE	NE	NE
DW105 (1 to 2 feet)	SQS	CSL	SQS	CSL	NE	NE	NE	NE	SQS	CSL	NE	NE	NE
Stations>SQS	6>SQS	--	1>SQS	1>SQS	--	--	--	--	1>SQS	1>SQS	--	1>SQS	--
Stations>CSL	--	3>CSL	--	4>CSL	1>CSL	1>CSL	2>CSL	1>CSL	--	2>CSL	--	--	1>CSL

Stations	Total LPAH	Fluor-anthene	Pyrene	Benzo(a)-anthracene	Chyrysene	Benzo(a)-pyrene	Ideno(1,2,3-Cd)pyrene	Dibenzo(a,h)-anthracene	Benzo(g,h,i)-perylene	Total HPAH	Total Benzo-fluoranthenes
DWPD-01	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
DWPD-02*	CSL	CSL	CSL	CSL	CSL	CSL	CSL	CSL	CSL	CSL	CSL
DWPD-03	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
DWPD-04	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
DWPD-05*	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
DW105 (0 to 1 foot)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
DW105 (1 to 2 feet)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

Stations	Total LPAH	Fluor-anthene	Pyrene	Benzo(a)-anthracene	Chyrysene	Benzo(a)-pyrene	Ideno(1,2,3-Cd)pyrene	Dibenzo(a,h)-anthracene	Benzo(g,h,i)-perylene	Total HPAH	Total Benzo-fluoranthenes
Stations>SQS	--	--	--	--	--	--	--	--	--	--	--
Stations>CSL	1>CSL	1>CSL	1>CSL	1>CSL	1>CSL	1>CSL	1>CSL	1>CSL	1>CSL	1>CSL	1>CSL

BBP = butylbenzylphthalate
BEHP = bis(2 ethylhexyl)phthalate
CSL = Cleanup Screening Level
NE = No Exceedance
PCB = polychlorinated biphenyl
SQS = Sediment Quality Standards
* High total organic carbon (TOC) for this sample; results for this sample compared on a dry weight basis to lowest apparent effects threshold (LAET) and second lowest apparent effects threshold (2LAET) criteria from the Lower Duwamish Waterway Group AETs.

3.2.2.2 Discussion of Sampling Results Before and After Construction Samples Beyond Site Boundary

The complete listing of analytical results for sediment samples collected before and after construction is included in Appendix J for dry weight values. A summary of all chemicals that exceed SMS criteria is included in Table 3, and individual results for PCBs are included in Table 4. Corresponding TOC and total solids values are also included in Table 4.

For PCBs, Table 3 shows that three stations (DW-01, DW-19, and DW-34) exceeded SMS criteria before construction, with all three stations greater than SQS criteria. After construction, the same three stations exceeded SQS criteria, and there were no exceedances of Cleanup Screening Level (CSL) criteria. Of the seven stations sampled after construction, four stations (DW-03, DW-13, DW-33, and LTBC20) had TOC values that were below the acceptable TOC value (0.5 percent dry weight TOC) for reporting data on an organic carbon-normalized basis. For these samples, accepted dry weight basis lowest apparent effects threshold (LAET) and second lowest apparent effects threshold (2LAET) criteria were used as shown in Table 3.

For bis(2 ethylhexyl)phthalate (BEHP), Table 3 shows that four stations exceeded SMS criteria before construction, with three stations (DW-01, DW-19, and LTBC20(J)Rep) greater than SQS criteria and one station (DW-34) greater than CSL criteria. After construction, there were no exceedances of SQS or CSL criteria for BEHP. For butylbenzylphthalate (BBP), Table 3 shows that four stations exceeded SQS criteria. After construction, there were no exceedances of SQS or CSL criteria for BBP. For mercury, Table 3 shows that three stations exceeded SMS criteria before construction, with one station (DW-34) greater than SQS criteria, and two stations (DW-01 and DW-19) greater than CSL criteria. After construction, there was one exceedance of SQS criteria (DW-19), and one station (DW-01) exceeded CSL criteria.

The most accurate way to identify changes produced by the two transport processes that affect chemical concentrations beyond the site boundary (i.e., dredge sediment transport and backfill sand transport) is to look for spatial differences in the change in dry weight concentrations at each station. To assist in this analysis, the stations in Table 4 were arranged in progressive order starting with the greatest increase and progressing to the largest decrease in PCB dry weight. In Figure 8, the observed changes in PCB dry weight values were plotted next to the station numbers to show the spatial differences. Dry weight concentrations increased at two stations (DW-01 and DW-19), and the increase observed at station LTBC20 (J) is too small (0.1 part per billion [ppb]) to be considered as a change in total PCB concentration. The highest increase (205 ppb) occurred at station DW-01, which is located approximately 350 feet north of the northern edge of the dredge prism boundary and downstream of the site. The second highest increase (126 ppb) occurred at station DW-19, which is located approximately 300 feet west of the western edge of the dredge prism boundary. While these values are potentially within the acceptable error of Aroclor analytical methods, the results indicate some increase likely occurred. The relatively low increases in PCB concentrations show that the migration of dredge material reached the outermost sampling stations and the direction of the migration correlates with the direction of tidal currents at the site.

Four stations (DW-03, DW-13, DW-33, and DW-34) showed a reduction in PCB dry weight values. A reduction in PCB values can occur when backfill sand is transported onto the station or contingency cover material is placed, which either buries all the underlying contaminated sediment (DW-13 and DW-33) or partially dilutes the 10-centimeter (cm)-deep sample (DW-03 and DW-34). A 6-inch layer of contingency cover sand was placed in an area that covered Stations DW-03, DW-13, LTBC20 (J), and DW-33 as shown in Figure 8. Station LTBC20 (J) showed no change in PCB concentration, while stations DW-03, DW-13, and DW-33 showed reductions in PCB concentrations (21.8 ppb, 79.4 ppb, and 8.62 ppb, respectively). The highest reduction in PCB concentration occurred upstream of the site at Station DW-34 where the PCB concentration was reduced by 203 ppb. It is reasonable to assume that sand migrated during or after the placement of backfill or contingency cover sand material to reduce the PCB concentrations near station DW-34 because backfill was predominately placed during flood tide and may have migrated in the upstream direction due to tidally influenced currents.

3.2.2.3 Discussion of Sampling Results for Post-Dredge Surface Samples Within Site Boundary

Ecology required surface sediment sampling inside and around the dredge boundary immediately following dredging activities in areas where backfill would be less than 3 feet thick, and these sample locations are shown in Figure 9. One subsurface core was also collected near the boundary of cleanup Areas A and B. The complete listing of analytical results for sediment samples collected after dredging activities at the post-dredge surface are included in Appendix J for dry weight values. A summary of all chemicals that exceed SMS criteria is included in Table 5.

For PCBs, Table 5 shows that five stations (DWPD-02, DWPD-03, DWPD-04, DWPD-05, and DW-105 [0 to 1 and 1 to 2 feet]) exceeded SQS criteria, and there were no exceedances of CSL criteria for PCBs. Of the six stations sampled after construction, two stations (DWPD-02 and DWPD-05) had TOC values that was above the acceptable TOC value (3.0 percent dry weight TOC) for reporting data on an organic carbon-normalized basis. For this sample, accepted dry weight basis LAET and 2LAET criteria were used to compare to SMS criteria.

For BEHP, Table 5 shows that two stations exceeded SMS criteria with both stations (DWPD-04 and DW-105 [0 to 1 and 1 to 2 feet]) greater than CSL criteria. For BBP, Table 5 shows that one station (DW-105 [1 to 2 feet]) exceeded SQS criteria.

For mercury, Table 5 shows that four stations exceeded SMS criteria at the post-dredge surface, with one station (DWPD-01) greater than SQS criteria, and three stations (DWPD-02, DWPD-04, and DW-105 [0 to 1 and 1 to 2 feet]) greater than CSL criteria. For cadmium, Table 5 shows that only one station (DWPD-02) exceeded the CSL criteria at the post-dredge surface. For silver, Table 5 shows that two stations (DWPD-02 and DW-105 [0 to 1 foot]) exceeded the CSL criteria. For lead and zinc, Table 5 shows that only one station (DWPD-02) exceeded the CSL criteria.

For acenaphthene, Table 5 shows that one station (DW-105 [1 to 2 feet]) exceeded the CSL criteria. For 1,4-dichlorobenzene, Table 5 shows that two stations (DWPD-04 and DW-105 [0 to 1 and 1 to 2 feet]) exceeded the SMS criteria, with one station (DWPD-04) greater than SQS criteria and one station (DW-105 [1 to 2 feet]) greater than CSL criteria. Numerous PAH compounds exceeded the SMS criteria at station DWPD-02 as shown in Table 5. Phenanthrene exceeded the SQS criteria at station DWPD-02, and fluorene, anthracene, total low-molecular-weight polycyclic aromatic hydrocarbons (LPAHs), fluoranthene, pyrene, benzo(a)anthracene, chyrysene, benzo(a)pyrene, ideno(1,2,3-Cd)pyrene, dibenzo(a,h)anthracene, benzo(g,h,i)perylene, total benzofluoranthenes, and total high-molecular-weight polycyclic aromatic hydrocarbons (HPAHs) exceeded the CSL criteria at station DWPD-02.

3.3. CONFIRMATIONAL MONITORING

Cleanup regulations require confirmational monitoring be performed to confirm the long-term effectiveness of the cleanup action, once cleanup standards and other performance standards have been attained (WAC 173-340-410 (c)). Long-term confirmation testing of the chemical levels on surfaces of cleanup Areas A and B began in April 2008, and will continue for 4 years until 2012. Sampling during the long-term monitoring will occur once each year. A separate report will be issued with the sediment chemistry results for each year sampled; however, Section 6 of this report details the April 2008 sampling effort at the one monitoring station on the backfill area. Appendix H details the long-term sediment monitoring sampling and analysis plan (KCDNRP 2008) for cleanup Areas A and B.

4.0 Surveys

4.1 PRE-CONSTRUCTION, POST-DREDGE, POST-BASE BACKFILL, AND POST-HABITAT MIX SURVEYS

King County hired an independent hydrographic surveyor (eTrac) to perform site surveys at key times during the project. Surveys were performed before construction began at the site, after the dredging was complete, after the base backfill layer was complete, and after the habitat mix layer was complete. These surveys were used to verify that the depths of dredging and elevations for backfilling were achieved as required in the Contract Documents. These surveys were also used as the basis for computing dredge quantities and base backfill layer quantities for contractor payment. Each survey was performed using a multi-beam survey-grade fathometer with survey lines approximately every 25 feet across the site. Tidal corrections were made based on periodic reading of an electronic tide gauge installed near the site at Pier 70. Horizontal location control was provided by using a DGPS that utilized the U.S. Coast Guard corrector station and locally surveyed monuments. The horizontal datum used in the surveys was North American Datum of 1983 (NAD83) and the vertical datum was the U.S. Army Corps of Engineers' MLLW. The King County surveys typically took less than half a day to acquire the survey data and less than 24 hours to process the raw data and approve the survey. Copies of the surveys are included in Appendix K; these surveys function as the as-builts required by MTCA (WAC 173-340-400(b)).

A reconnaissance survey was performed on September 10, 2005, by Blue Water Engineering. This survey was used to develop the final plans included in the Technical Specifications. A confirmational pre-dredge survey was performed on October 30, 2007. The post-dredge survey was performed on January 13, 2008. The post-base backfill survey was performed on February 4, 2008. The post-habitat mix survey was performed on February 15, 2008.

4.2 CONTRACTOR DAILY PROGRESS SURVEYS

As described in the Contract Documents, the contractor was required to perform daily progress surveys over the entire area dredged to date during dredging operations, but typically the contractor performed the progress surveys two to three times per week. The contractor used a Hemisphere V10 DGPS receiver for horizontal positioning and a single-beam Odom Echotrack dual-frequency survey-grade echosounder for recording water depth. Laptop computers with Hypack® software processed the data. Soundings were corrected for the tides based on a project-established electronic tide gauge at Pier 70. The contractor performed a pre-dredge survey about 1 month after eTrac performed King County's pre-dredge survey. The two surveys were in substantial agreement. The contractor's final post-dredge survey was also in substantial agreement with eTrac's post-dredge survey.

During backfilling operations, the contractor's progress surveys were used to monitor whether each backfill layer had adequate thickness. The contractor's final post-base backfill survey agreed with the eTrac post-base backfill survey.

4.3 QUANTITIES

A comparison between the pre-dredge survey and the post-dredge survey shows that 14,376 cy were removed during the entire project (including the debris and overdredge quantities). The final pay volume for the dredging portion of the work was 13,701 cy. The backfilling quantities were measured by material type and paid by different units of measurement as shown in Table 6. The contractor delivered and placed 11,886 cy of base backfill, 4,821 cy of habitat mix (paid as lump sum), 758 tons of armor rock (light loose riprap), and 8,815 square yards of contingency cover material (Table 6). These quantities were measured either by hydrographic survey, at the quarry based on barge displacement and using certified displacement curves, or by using bucket mark maps to confirm square yards placed.

Table 6
Quantities of Backfilling Materials

Material Type (Paid Unit)	Original Bid	Revised Estimate	Final Construction	Final Pay Quantity
Base Backfill (CY)	12,800	10,810	11,886	11,886
Habitat Mix (LS)	Lump Sum	Lump Sum	4,821	Lump Sum
Rock Armor (TON)	--	--	758	758
Contingency Cover (SY)	6,200	8,815	8,815	8,815

CY = cubic yards
LS = lump sum
SY = square yards

5.0 Deviations From Plans

The following deviations were noted from the Design Analysis Report (Anchor 2007b), Contract Drawings, and Technical Specifications and were approved by Ecology:

- Request for Change Order No. 001 (RCO No. 001) stated that the concrete material present on the upper slope of the dredge prism along the sea wall was considered to be a change of site conditions. The change order included a scope of work and revisions to the Contract Drawings (C102 to C105) that revised the dredge side slopes and cross sections. The modifications to the dredge plan and target base backfill plan are shown in Figures 3 and 5 respectively. The revision included modifying the toe of the dredge cut along the shoreline, and steeping the dredge cut to a planned 1H:1V. The revision minimized the removal of concrete material in the upslope area and reduced the dredge prism volume from approximately 17,100 cy to 15,100 cy, or a difference of 2,000 cy. The scope of work required the contractor to remove and dispose of concrete debris present in the revised dredge footprint that was acting as slope armoring, and furnish and replace armor rock as determined by the engineer.
- The habitat mix placed on site did not meet the Technical Specification for Habitat Mix material. The material specified was not readily available at the time of constructing the habitat mix layer, and an alternative habitat mix specification was approved by the Washington Department of Fish and Wildlife (WDFW):

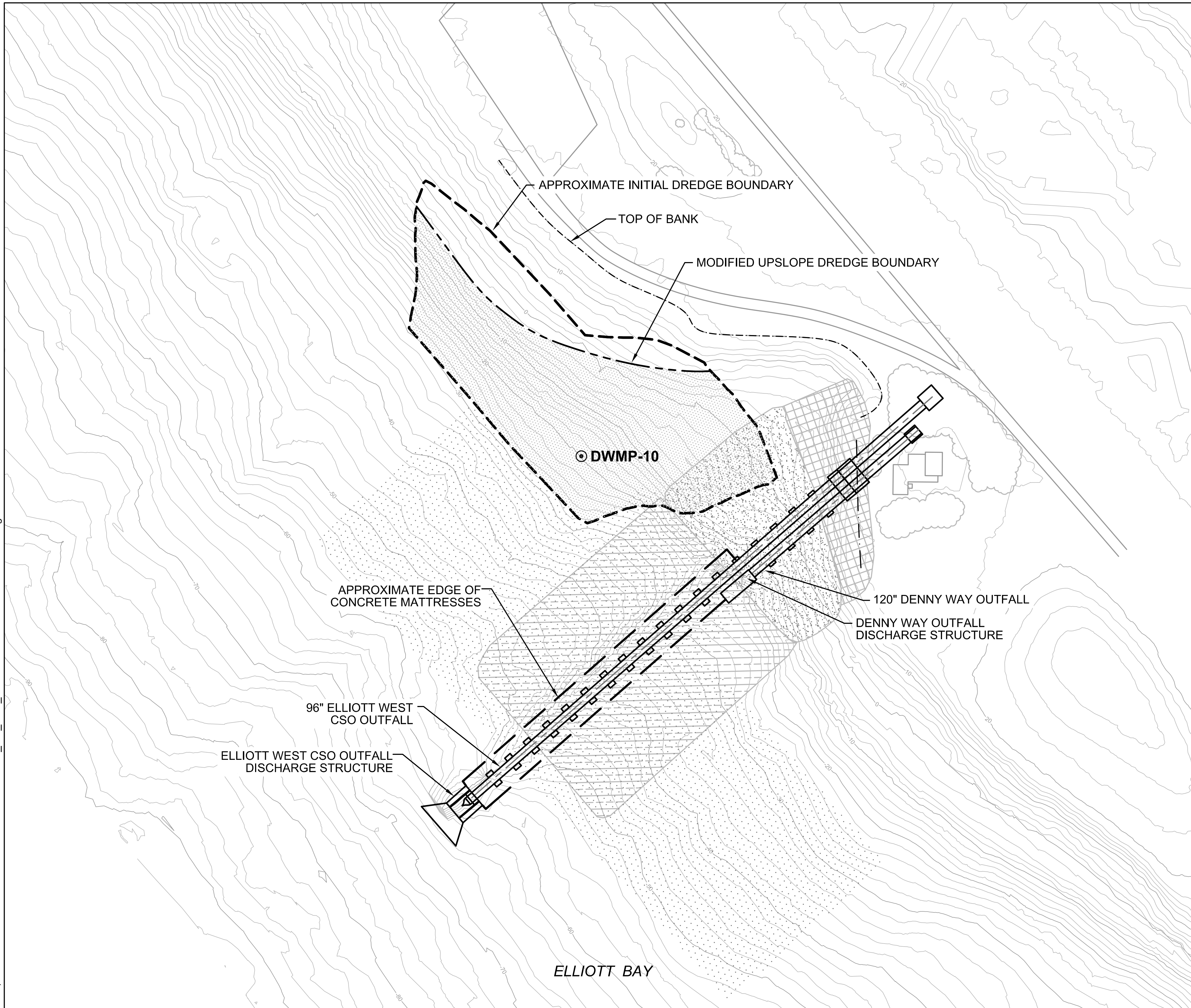
Size	Percent Passing
2”	100
1.5”	80-95
¾”	50-80
US No.4	30-50
#200	0-8

  The change helped the contractor stay on schedule.
- Contractor progress surveys were required to be performed daily by the Technical Specifications. The contractor requested to decrease the progress survey frequency, reducing the number of surveys to three per week to improve the contractor’s construction schedule. King County agreed that this reduced survey frequency was acceptable, which ultimately helped the contractor’s schedule.
- The contingency layer was placed based on the results of sampling before backfilling instead of based on post-construction sampling as contained in the Technical Specifications. King County requested this change because, at that time, the backfilling (and post construction sampling) was not projected to be completed before the end of the fish window. An extension to the fish window from February 16 to February 28 was requested from WDFW and received. Taking the samples pre-backfill allowed the decision on whether or not to place the contingency cover to be made prior to completion of backfilling and reduced the period the project extended into the fish window (5 days) by up to 7 days.

6.0 Post-Construction and Long-Term Monitoring

6.1 SEDIMENT CHEMISTRY STATION ON BACKFILL SURFACE IN CLEANUP AREAS A AND B

The *Denny Way CSO and Elliott West CSO Treatment Facility, Post Operation Sediment Monitoring, Year 3, Denny Way CSO Areas A and B Nearshore Sediment Remediation Project Post-Construction Sediment Monitoring, Areas C, D, and E Monitoring Sampling and Analysis Plan* (KCDNRP 2008) is included in Appendix G and contains long-term monitoring requirements for changes in the surface sediment chemistry of one station within cleanup Areas A and B to evaluate the potential for recontamination of the backfill over time. Surface samples will be collected from station DWMP-10 annually in April for a 5-year period, from 2008 through 2012. Figure 10 shows the one surface sediment monitoring station located in Area A. An attempt to collect the first-year baseline sample was conducted on April 1, 2008 (Year 0 sampling event). Three casts of the grab sampler that produced only rock and gravel were made at Station DWMP-10, and no collectable sediment was available. Station DWMP-10 is located in an area covered with habitat mix that contains a large amount of gravel and makes it difficult to collect a representative sample. No sample was submitted to the laboratory for this station for this year.



NOTES:
1. FIGURE PREPARED FROM DRAWING PROVIDED BY BLACK & VEATCH CORPORATION ENTITLED "HABITAT RESTORATION PLAN", DATED NOVEMBER 1999.
2. BATHYMETRY PREPARED FROM SURVEY PROVIDED BY BWE DATED SEPTEMBER 10, 2005.
3. HORIZONTAL DATUM: SP NAD 83/91 WA N
4. VERTICAL DATUM: MLLW

Jun 30, 2008 9:01am cdavidson K:\Jobs\020067-KING_CO_SED_MANAG\02006701\02006701-126.dwg FIG 10

ANCHOR ENVIRONMENTAL, L.L.C.

Figure 10
Backfill Monitoring Station for Areas A and B
Denny Way CSO Nearshore Interim Sediment Cleanup Project

7.0 Summary of Lessons Learned

Overall, the cooperation of project personnel helped the construction stay on schedule, and the cleanup was completed in a relatively short construction window. A longer construction window may have improved contractor bid response, would have eased the schedule, and may have allowed for stricter enforcement of the Technical Specifications (e.g., required contractor daily progress surveys, contractor sourcing habitat mix that met the material specification). Increases in bid responses from contractors may also improve with a decrease in King County's insurance requirements, which are generally higher than the industry standard.

The change order was effectively managed with a modification to the design that minimized the increase in project costs from the change order, but could have included strengthened performance language pertaining to the use of the excavator that was used to remove pieces of armor rock and concrete. Collection of more information before the design phase that would assist in delineating the armor rock and concrete area may have clarified the design, but could have also increased bid prices. In addition, further delineation of the armor material or for "debris" in general may not have actually averted a change order. A separate bid item for the removal of the armor rock and concrete would have allowed for a more complete evaluation of the contractor's interpretation for this portion of the work.

Overdredging during marine construction is currently being subjected to more public and regulatory agency (e.g., Corps) scrutiny, and the daily contractor surveys provide more timely evidence of overdredging; therefore, it is important to receive these progress surveys in the schedule specified in the Technical Specifications in order to effectively minimize overdredging.

The method of offloading sediment at the offloading facility was effective at maintaining a clean operation, but influenced dredging production because of slower offloading rates. To improve offloading rates under this scenario, available land could be leased to store containers loaded with sediment, so that sediment could be offloaded from the material barges independent of the transportation schedule of available trains destined for the landfill.

King County introduced the use of the real-time water quality monitoring buoys on this project and the buoys were viewed as a success by project personnel and regulatory agencies (i.e., Ecology). The frequency of data available in real-time allowed for close monitoring of the water quality impacts due to construction activities. The shortcomings of using a stationary buoy are that it may not be the most accurate water quality indicator because turbidity plumes may not be measured at the correct depth or location. Increasing the number of sondes on each buoy may be beneficial to future projects so that water quality is characterized for more of the water column.

8.0 Affidavit

The interim cleanup action for the contaminated sediments at the Denny Way CSO Nearshore Interim Sediment Cleanup Project site in Elliott Bay has been completed in substantial compliance with the Design Analysis Report dated July 2007 and the Technical Specifications dated August 2007.

John Laplante, P.E.
Project Manager
Anchor Environmental, L.L.C.

9.0 References

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Appendices

Appendix A.	Photos
Appendix B.	Contractor Daily Reports
Appendix C.	King County Inspector Daily Reports
Appendix D.	Hourly Averaged Water Quality Monitoring Data
Appendix E.	Complete Daily Water Quality Reports from Water Quality Monitoring Stations
Appendix F.	Water Quality Monitoring Sampling and Analysis Plan
Appendix G.	Dredging and Backfilling Operations Sediment Monitoring Sampling and Analysis Plan
Appendix H.	Denny Way CSO and Elliott West CSO Treatment Facility, Post Operation Sediment Monitoring, Year 3, Denny Way CSO Areas A and B Nearshore Sediment Remediation Project Post-Construction Sediment Monitoring, Areas C, D, and E Monitoring Sampling and Analysis Plan
Appendix I.	QA1 Reports
Appendix J.	Lab Reports
Appendix K.	eTrac Engineering, L.L.C. Surveys