SEDIMENT REMOVAL AND CAPPING OF THE LOCKHEED SHIPYARD SITE WEST DUWAMISH WATERWAY USING CONVENTIONAL DREDGE EQUIPMENT

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ABSTRACT

A 1982 EPA inspection of a lead smelting facility formerly operating on Harbor Island identified lead contaminated soils. This discovery led to the listing of the entire island, including sediments in the adjacent waterways. The LSSOU is one of ten operable units designated for the Site.

A Phase 1 Remedial action was performed that included demolition of pilings, piers, and an existing wood bulkhead, bulkhead replacement, dredging to allow cap construction in slope areas (under pier), dredging sediments that exceed the Washington State Sediment Quality Standards (SQS) in the Open Channel Area. Prior to completion of the Phase 1 Remedial Action, confirmatory composite surface grab samples (0 to 10 cm) were take from 6 of the 17 Sediment Management Units in the open channel area. The grab samples showed the surface sediments within the 6 SMU's at the south end of the site did not meet the requirements for the SQS. In some cases the measured concentrations of chemicals of concern (COC's) were greater than previous data.

Based on the sampling results, a Phase 2 dredging and capping was required. Prior to the start of the Phase 2 dredging and capping operation, another round of coring was conducted between May 20 and May 28, 2004. The project remediation was then completed using a larger, conventional clamshell and haul barge equipment.

This paper reviews the phase 2 remedial actions, and the general impacts and conditions the phase 1 effort created that had to be considered in the revised phase 2 plan.

Keywords: Two-pass dredging, confirmation samples, resuspension, residuals, Win-Ops, bucket plan, habitat mix

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INTRODUCTION

The Lockheed Shipyard Sediment Operable Unit (LSSOU) is located in the West Duwamish Waterway (West Waterway) adjacent to Harbor Island, approximately 2 miles southwest of downtown Seattle. The LSSOU consists of the intertidal and subtidal areas underneath piers and shipways associated with the former Lockheed Shipbuilding shipyards and in a selected area of the open channel (Figure 1).

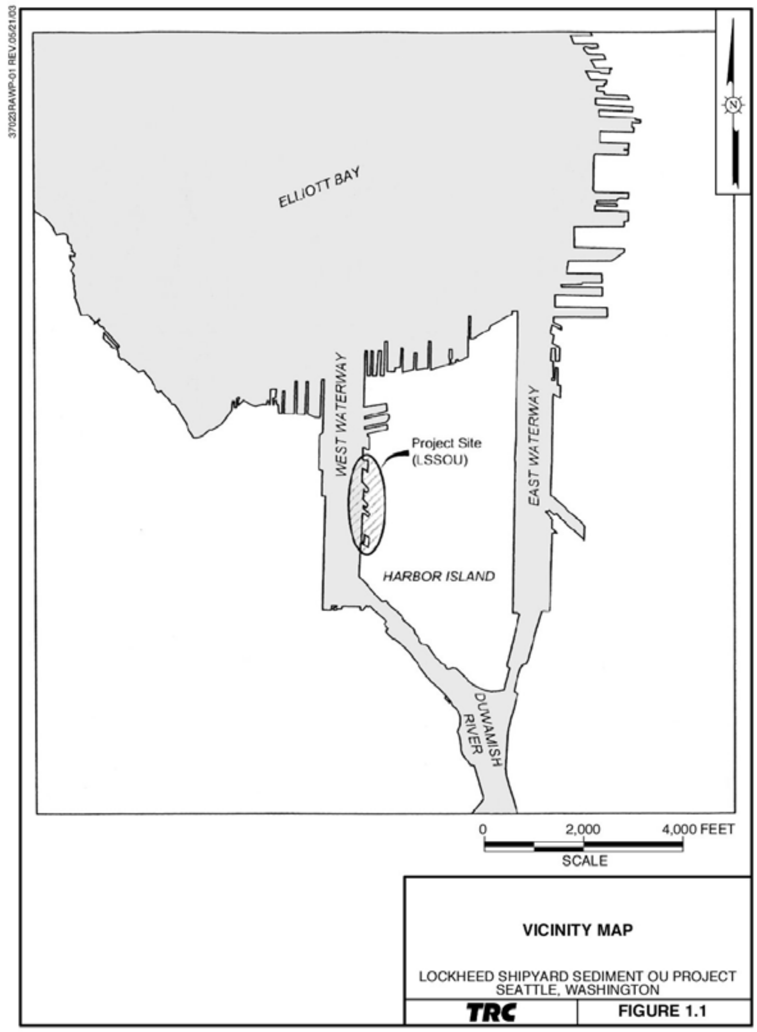

Figure 1. Vicinity map.

The 430 acre Harbor Island has supported industrial uses since it was constructed in the early 1900's. Prior to 1905, the area consisted of tide flats with a few piling-supported structures, predominantly railroad trestles. The island was created between 1903 and 1905 with dredged material from straightening of the Duwamish River into the Duwamish Waterway. Industrial use of the site has included bulk petroleum storage, shipbuilding and repair, cargo handling, smelting operations, and metal recycling and fabrication.

A 1982 EPA inspection of a lead smelting facility formerly operating on Harbor Island identified lead contaminated soils. This discovery led to the listing of the entire island, including sediments in the adjacent waterways. The LSSOU is one of ten operable units designated for the Site.

This report provides information on the project remediation starting at the time that Phase 1 Remedial Action was completed, and the confirmation samples were obtained.

PHASE 1 REMEDIAL ACTION

A Phase 1 Remedial action was performed by TRC Solutions, Inc. That work was to include demolition of pilings, piers, and an existing wood bulkhead, bulkhead replacement, dredging to allow cap construction in slope areas (under pier), dredging sediments that exceed the Washington State Sediment Quality Standards (SQS) in the Open Channel Area, and addressing the Contingency Area. Following dredging and compliance with the SQS in the open channel area, a 5 ft thick, three layer cap was to be constructed on the slope area (Figure 2).

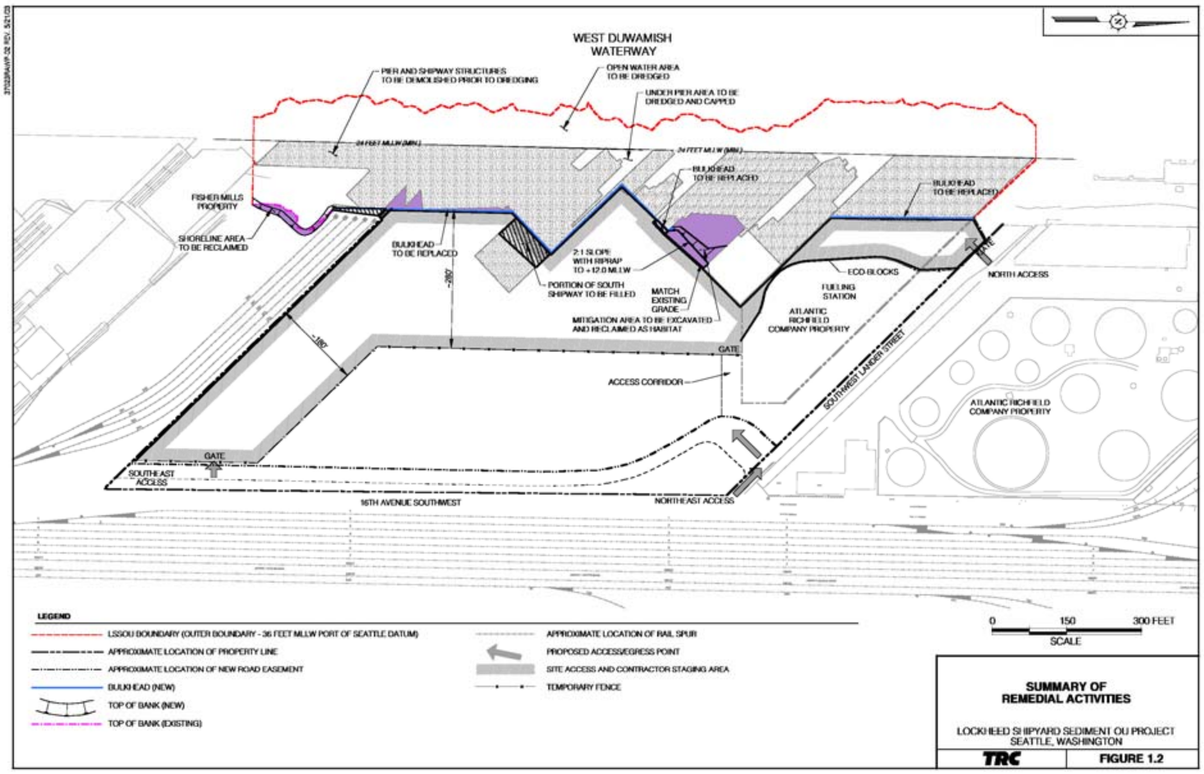

Figure 2. Summary of remedial activities.

Prior to completion of the Phase 1 Remedial Action, confirmatory composite surface grab samples (0 to 10 cm) were take from 6 of the 17 Sediment Management Units in the open channel area. The grab samples showed the surface sediments within the 6 SMU's at the south end of the site did not meet the requirements for the SQS. In some cases the measured concentrations of chemicals of concern (COC's) were greater than previous data.

Based on the failure of the confirmation samples to meet SQS, additional cores were collected to investigate the depth of contamination at 11 locations within the Open Channel Area. Preliminary results of this initial round of core samples indicated that a layer of light, "fluffy" material having high water content was apparently redeposited from dredging operations over clean native material in many areas. Some of the cores showed the presence of deeper contaminated material that appears to have not been dredged. At the completion of the first dredging season (Phase 1) the entire dredged area was capped with a relatively thin layer of pea gravel and coarse sand to stabilize the site and prevent biological exposure or contaminant migration.

Preliminary investigations and review of work performed during Phase 1 indicated that failure to attain the SQS in the open channel area and remove all the debris was likely due to two principal causes; redeposition of sediments that were resuspended during dredging and failure to remove all in-place contaminated sediments. The failure to remove all in-place contaminated sediments was most probably caused by a combination of two factors: (1) The design dredge elevations were not achieved due to difficult dredging conditions not foreseen during the Phase 1 project planning and design and (2) the Phase 1 dredge design did not provide for deep enough cuts to remove all contaminated sediments in the open channel area. It was also concluded that the relatively small mechanical dredge plant (3.5 cu yd bucket) that was used was not sufficiently effective for the dredging and debris conditions.

PHASE 2 REMEDIATION DREDGE DESIGN/OPERATIONS PLAN

Prior to the start of the Phase 2 dredging and capping operation, another round of coring was conducted between May 20 and May 28, 2004. The sampling was done after placement of the pea gravel and coarse sand cap. Sampling in this material was difficult for core recovery. Forty proposed core locations in the open channel area were laid out in a triangular grid arrangement. Cores were collected at 36 locations within the Open Channel Area. Duplicate cores were collected at three of the locations.

Sediments in each of the collected cores were described and classified as cap material, non-native, native or indeterminate. Rounded pea gravel and coarse sand found near the surface of the cores was identified as cap material. Non-native sediments included dark stained angular gravels, sands, and silts with shipyard or wood debris, including sand blast aggregate. The presence of oil sheens was also noted in non-native sediments. Native sediments included dark to medium gray fine sands and silts, frequently with interbedded layering. Sediments identified as native were never found overlying non-native sediments or sediments of indeterminate origin. Sediments identified as indeterminate included finer grained sediments with wood debris, disturbed layering, with patchy dark staining or scattered pieces of angular gravel or debris.

Seventy eight samples were analyzed for selected metals (arsenic, copper, lead, mercury and zinc). Twenty seven of the samples were also analyzed for polychlorinated biphenyls (PCBs), low and high molecular weight polycyclic aromatic hydrocarbons (LPAHs and HPAHs), and total organic carbon (TQC). Forty eight of the samples had one or more exceedances of the SQS for metals. There were no PCB, LPAH or HPAH exceedances of the SQS (Figure 3).

The vertical and horizontal distribution of contamination across the site was highly variable and did not show any consistent patterns regarding changing metal concentrations or estimated depth to clean sediment (SQS criteria). At each coring location the depth below the current cap surface to the native sediment interface was determined. In addition, if a sample collected above the native interface was found to be clean then the depth to clean sediment was also determined. The estimated depth to clean or native sediment contact, whichever was less, was assigned to the area within a polygon. Dredge cuts were then developed to remove the potentially contaminated material within each polygon.

The phase 2 dredging operating plan called for the use of a conventional bucket dredge. Based on the limited success of the smaller clamshell dredge during the Phase 1 dredging, a significantly larger dredge was specified. The dredge that did the Phase 2 work was the dredge Mukilteo, with a five cubic yard standard clamshell bucket for the first cut, and a 7 cubic yard closed environmental bucket for the second pass.

The dredge cuts were developed as a two pass dredging plan. The concept was to remove the surface 2 to 4 feet of problem sediment by a standard digging bucket in a more cost effective manner that would more effectively deal with any debris encountered. The second phase was targeted to remove approximately one foot of material plus one foot of overdepth to an elevation that was below the identified elevation of contamination. This phase was accomplished using a closed environmental bucket.

Figure 4 depicts the first and second pass dredge plan. The first dredge pass cut elevations that were approximately one foot or less above the elevation of contamination. The cuts were level, reflecting the standard method of operation for a clamshell bucket. The cuts extended from the toe of slope out to the contour depth equal to the elevation of the cut along the Duwamish Waterway. During the first pass, the contractor was required to remove debris, and leave approximately 2 feet of required dredging for the second pass. The required total depth of dredging was at least 1 foot below the depth of contamination. The over depth dredging below the required depth averaged 0.8 feet.

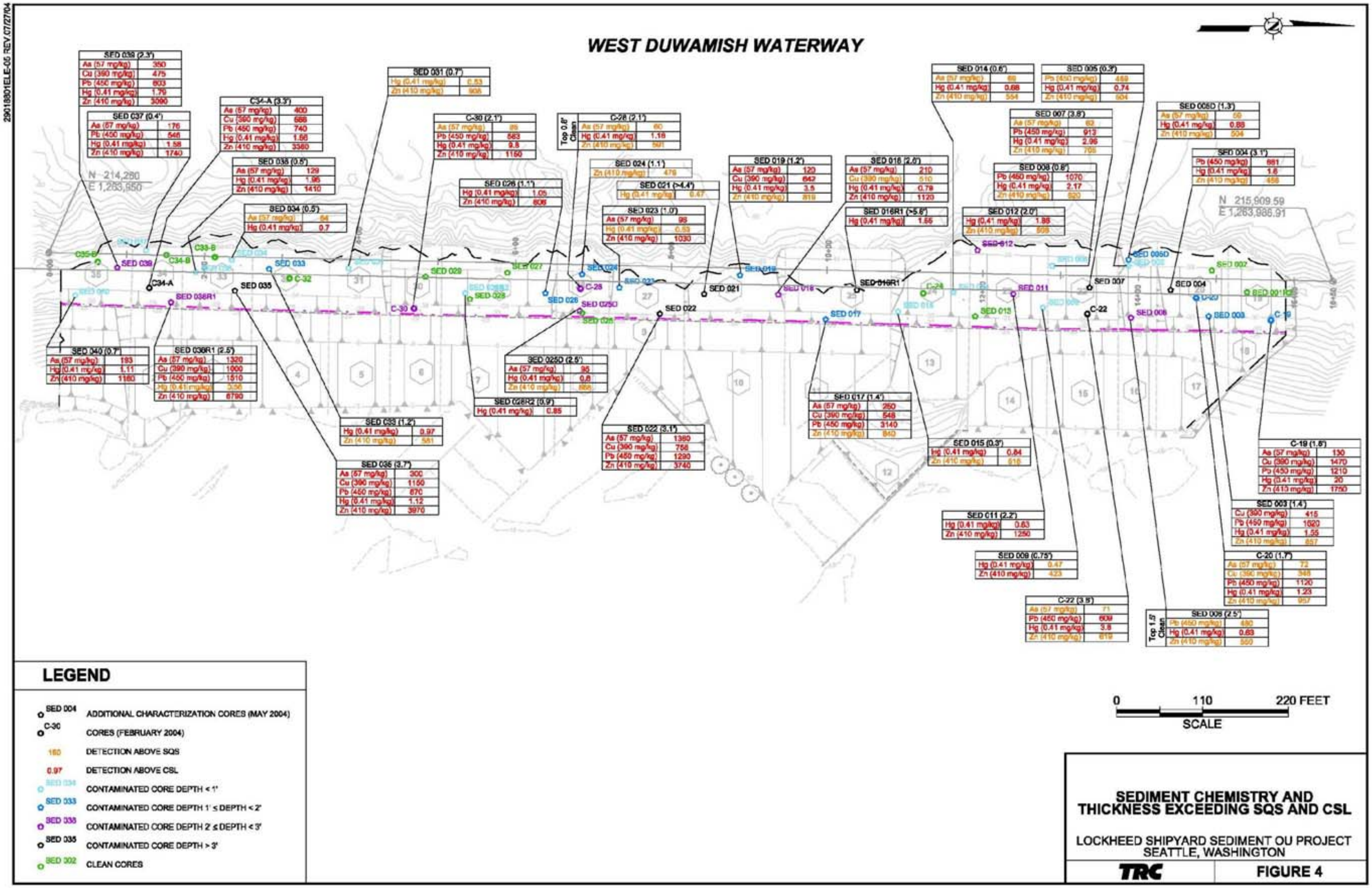

Figure 3. Core locations 2004 chemistry and depth to clean material.

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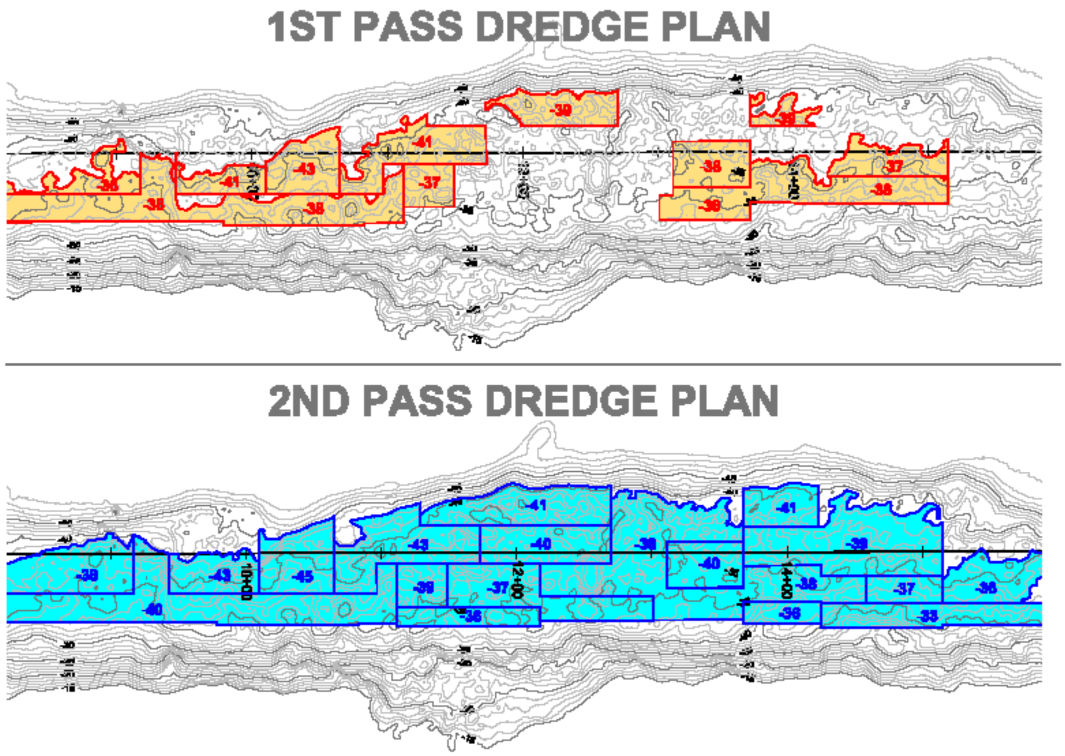

Figure 4. 1st and 2nd pass dredge plan.

The dredger was required to use the WinOps positioning package to control the xy and z position of his bucket. A plan for each bucket position was developed before the first pass and the second pass dredging. The Operator positioned each bucket on the bucket plan position, and removed the required sediment. Because the dredge cuts were shallow (3 feet and 2 feet typical), almost all material was removed with only one bucket grab. Figure 5 depicts a typical bucket plan.

The bucket plan included a minimum overlap for most side by side bucket grabs. The Clamshell Dredge was of typical design, with the bucket placed on a circular pattern. Small areas on the bed surface were not covered by the bucket grab pattern. The operator would position his bucket to take a bucket grab on these locations; thereby assuring the entire area was excavated. The dredging was completed from shallower to deeper bed elevations in an attempt to limit sloughing and residual contamination.

After dredging to design grades and elevations had been accomplished according to WinOps output as confirmed by hydrographic surveys, core sampling to demonstrate compliance with SQS was conducted. Termed "Progress Samples" the sampling protocol called for two cores to be taken in each of the 17 open channel dredge management units. The cores were logged and samples taken below the top 10 cm layer if there was any doubt that native material had been reached. The top 10 cm from each of the two cores was combined into a composite for analysis. Sample splits were archived from each of the cores to be analyzed in the event the composite failed the SQS.

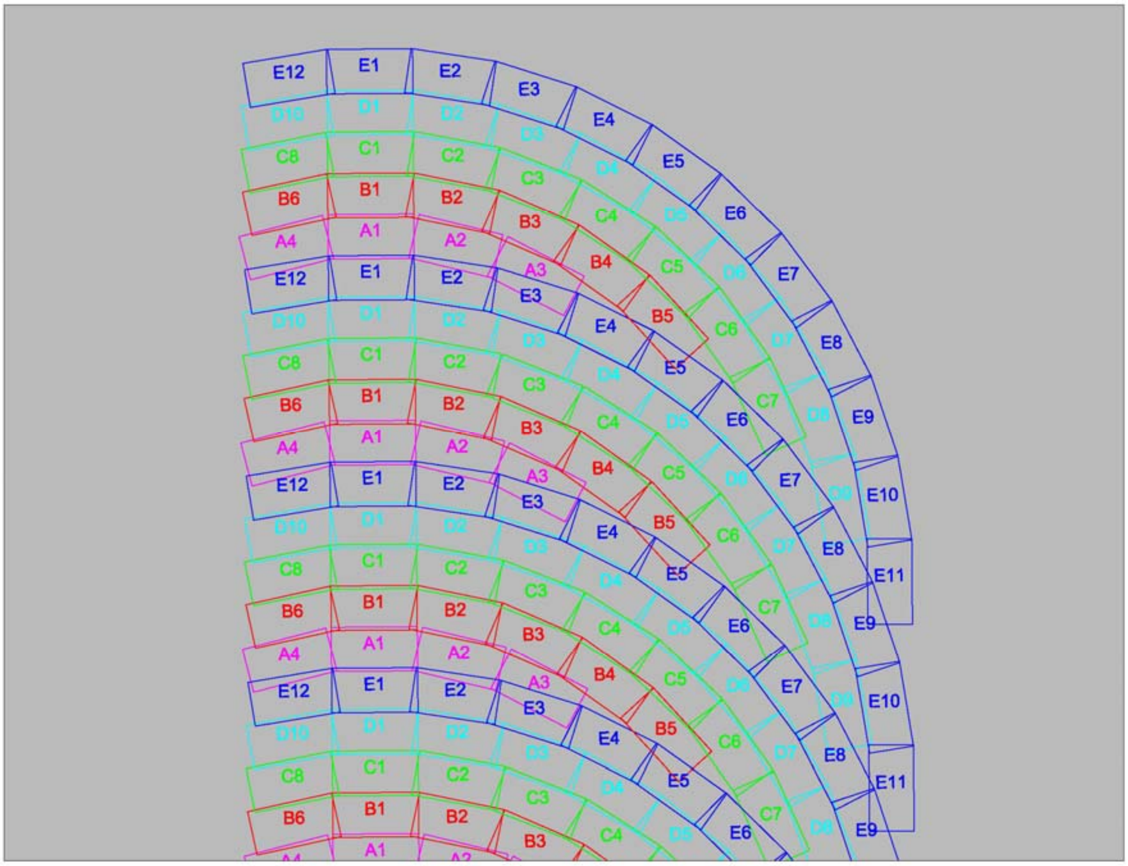

Figure 5. Bucket plan.

Initial results indicated that nine of the 17 dredge units either met the SQS or met the SQS for all metals except for Mercury, which was deemed to be very close to the SQS. The remaining 8 units were dredged to some degree based on the results of analyzing previously archived samples which allowed area and depth targets to be established. Following the final cleanup dredging pass, grab samples were taken in each of the eight areas in the locations of previous progress cores for comparison purposes. One area continued to indicate elevated levels of shipyard metals and was eventually covered with a relatively thin layer of sand to provide enhanced natural recovery (ENR) at the completion of slope capping. Two other areas showed high Mercury values only, and were also treated with ENR material.

PHASE 2 CAPPING

Sediment capping for containment purposes was identified as the technology for final remediation of the slope area. The Record of Decision on the site explicitly states that sediments containing COC's above Cols and shipyard waste must be dredged and disposed. Capping could not be implemented in the Open Channel area, at least not as a stand-alone remedial technology.

Figure 6 depicts the overall plan for cap placement in phase 2. Figure 7 is a typical cross section of the dredging and capping plan. The initial placement of the buttress rip rap at the toe of the slope was completed. The buttress rip rap was placed by the dredge Mukilteo using a standard 5 cubic yard bucket. Two flat deck barges supplied the rip rap material. The rip rap was released at or near the bed for control of placement. The Buttress was built to a typical elevation of five feet above the dredge bed elevation. See Figure 7, a typical cross section. The final placement depths were confirmed by multibeam surveys, and by lead line soundings.

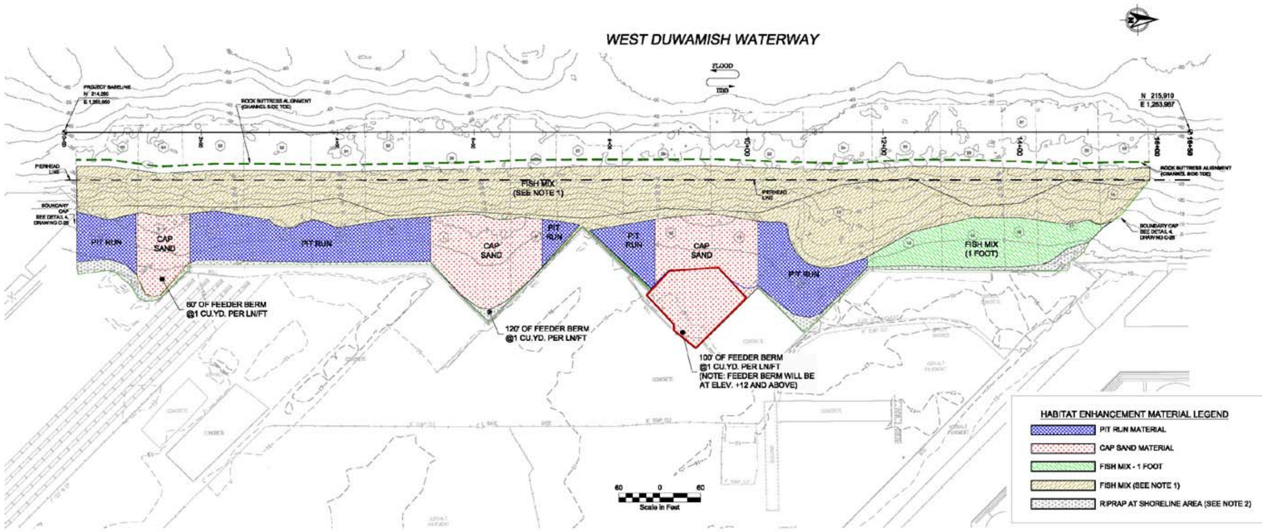

Figure 6. Capping plan, phase 2.

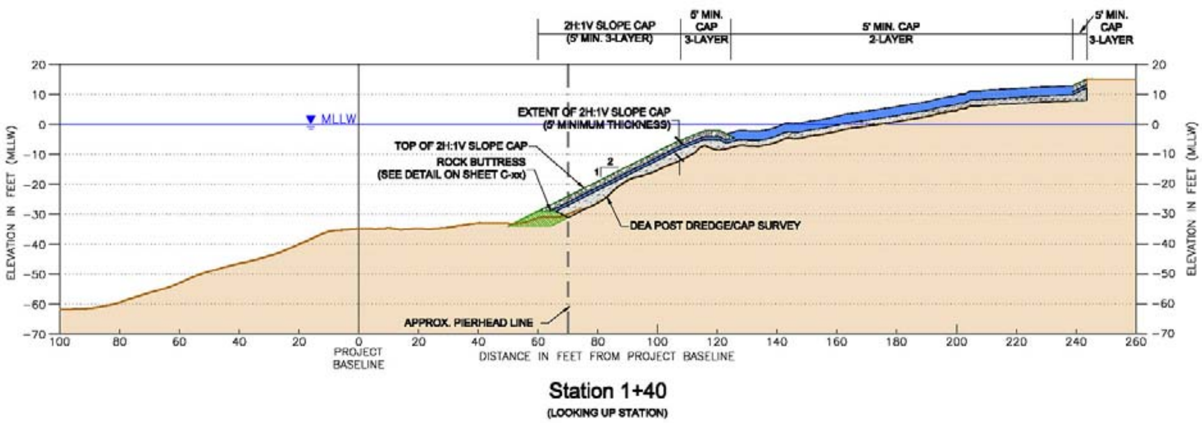

Figure 7. Typical cross section for dredging and capping.

The cap consisted of a typical three layer design. The bottom layer was characterized as a cap material, and was predominantly gravelly sand. Beginning at the toe of the slope, along the buttress toe, the gravelly sand cap was place upslope to the bulkhead. This cap material was placed with a 7 cubic yard rehandle bucket. The operator opened the bucket to allow the material be released in a controlled manner at the water surface in order to minimize disturbance at the bottom. The cap was placed in approximate 6 inch lifts. The xy position release of the cap materials was documented on WinOps software. This cap material was placed in four lifts to provide a 2 foot thick cap layer of gravelly sand. The sediment thickness confirmation was accomplished by multibeam survey.

The second layer of cap material was the Filter material. This filter material layer was sandy gravel sediment. It was also placed starting at the buttress toe, and progressed up the slope as was the first cap layer. This filter layer was only 1 foot thick in the areas where armor cap was subsequently placed. It was 3 feet thick at the top of slope where the slope grade was less than 1 on 5, and no armor layer was required. Reference the capping plan, figure xx. The filter layer placement control was provided by mutlibeam surveys every other day, and supplemented by tracking tonnage applied per area and lead line soundings.

The third layer of cap placed was the armor cap. This was a two foot thick armoring layer of small rip rap placed on the slope with a grade steeper than 1 on 5. The armor layer control was again provided by multibeam survey, and by tracking tonnage applied per area, and lead line soundings.

Rip Rap was also placed along the shoreline sheet pile bulkhead to form a 2:1 slope for the finish grade of +8 feet to +12 feet mllw. This material was placed by upland equipment after the filer material was in place.

At the end of the rip rap armor layer capping, the rip rap was covered with a habitat mix in accordance with planned rates identified by the State. This habitat material was placed from the water side as was the general cap. The material placement was documented by tonnage per area.

PROJECT CONCLUSIONS

Overall production fell behind at the approximate 75% stage of project completion. The decision was made to place the gravelly sand cap material along the shoreline using land based equipment. This would provide time savings to meet the fish window closure date for the waterway. The equipment selected was a spreader discharge at the end of a conveyor system. The conveyor was able to extend beyond 100 feet and place the gravelly sand cap material. One operator kept the hopper full with a front end loader. The second operator used a remote control to swing and extend the conveyor system.

This system worked very well. The cap material was placed in one foot high rows. All placements were completed during low tides. All low tides occurred during the night time, and adequate lighting was required. A concern was expressed by EPA that sorting of the cap material may occur. This was not a problem for the cap mix that was used.

Some difficulty did arise with the use of the multibeam survey system and a single fathometer survey system at the start of the dredging. The two survey systems did not provide a record of the same elevations for the slope areas. This was due to the cone angle of the single fathometer, with the return recording of the shallowest sounding on the slope. All of the pre and post surveys were finally collected by multibeam to assure consistent comparison and accuracy of surveys.

The dredging and capping were relatively very successful for this dredging event. The cap material of pea gravel that was placed on the site after the previous years dredging proved to be very instrumental in the successful dredging the second year. The cap material did tend to consolidate the bed material, such that the bucket grabs for this final dredging were significantly less turbid than the previous years dredging.

A limited amount of debris was found in this dredging event. The larger dredge size allowed the easy removal of this debris, and little consequence to the overall operation. This was vastly different from the previous years dredging efforts.

The other reason for a successful dredging and capping event was the simple fact that a very good operator was on the dredge. He worked the project as a remediation project, and not a navigation project. He took time to be sure the bucket was properly placed, he controlled the depth of excavation to the extent possible, and he allowed some drainage of water at the water surface before placement of the bucket load in the barge. This one person’s capability is vital to the success of any remedial dredging and capping activities.