WATER QUALITY MONITORING DURING CAPPING AT THE PACIFIC SOUND RESOURCES SUPERFUND SITE, MARINE SEDIMENTS OPERABLE UNIT, SEATTLE, WASHINGTON

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ABSTRACT

The Pacific Sound Resources Superfund Site Marine Sediments Operable Unit (MSU) encompasses approximately 58 acres of the south shore of Elliott Bay in Seattle, Washington, along approximately 2,000 feet of shoreline. The site was formerly known as the Wyckoff West Wood Treating Facility; from 1909 to 1994, wood-treating operations were performed at the site. The MSU was contaminated by creosote and wood-treating chemicals from historical wood-treating operations on the upland portion of the site. Primary chemicals of concern in the MSU are polycyclic aromatic hydrocarbons and polychlorinated biphenyls.

The selected MSU cleanup alternative specified in the Record of Decision (dated September 30, 1999) consists of capping and a small amount of dredging. Remediation is being conducted under the Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986.

The MSU was subdivided into remediation areas according to specific site conditions, including operational conditions that affect remedy implementation. As part of the remediation effort, work was performed in six of these areas during the 2003/2004 and 2004/2005 in-water construction seasons. Capping, dredging, and other in-water construction activities were performed by American Civil Constructors-West Coast under contract to the U.S. Army Corps of Engineers. Dredging was performed to maintain navigation depths, and a sediment cap was placed.

Blasland, Bouck, & Lee, Inc. performed water quality monitoring during the 2003/2004 and 2004/2005 capping, dredging, and other in-water activities. The objective of the water quality monitoring was to assess potential short-term water quality impacts from capping, dredging, and associated in-water construction activities and to invoke corrective actions, if necessary, to bring construction activities into compliance with water quality criteria.

Water quality monitoring consisted of background and compliance monitoring for turbidity, temperature, dissolved oxygen, and total suspended solids. Water quality monitoring was performed during dredging by environmental clamshell bucket and during capping with skiff box, excavator, backhoe, stern of the barge, and bottom dump barge. Cap material ranged in grain size from silt to riprap. A variety of cap materials were used, including borrow material from a glacial gravel mine, dredged material, borrow material from a limestone mine, and a carbon additive to increase organic contaminant sorption capacity. Cap material was placed in water depths ranging from about 10 feet to -200 mean lower low water.

This presentation summarizes water quality monitoring results and evaluates water quality monitoring during different cap placement methods. Given the variety of cap placement methods and cap materials, the wide range in water depth, and the long schedule of the project, an adaptive management approach was taken to evaluate water quality results. Compliance monitoring results were compared to background monitoring results that were collected throughout the project. Blasland, Bouck & Lee, Inc.; American Civil Constructors-West Coast; and the U.S. Army Corps of Engineers communicated frequently to proactively meet data quality objectives. The adaptive management

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approach used at Pacific Sound Resources Superfund Site can effectively be applied to other dredging, capping, and in-water construction projects.

Keywords: dredging, water quality compliance, dissolved oxygen, turbidity, total suspended solids

INTRODUCTION

The Pacific Sound Resources Superfund Site Marine Sediments Operable Unit (MSU) encompasses approximately 58 acres of the south shore of Elliott Bay, an estuarine water body in Seattle, Washington, along approximately 2,000 feet of shoreline (Figure 1). The site was formerly known as the Wyckoff West Wood Treating Facility; from 1909 to 1994, wood-treating operations were performed there. The wood-treating facility was originally a pile-supported facility over the Duwamish River estuary. During the last century, the shoreline and intertidal areas were filled until, ultimately, the entire facility was located on created uplands. A remedial investigation/feasibility study was completed for the site, including both the Upland Unit and the MSU, in April 1998. Active cleanup in the Upland Unit has been completed. The selected MSU cleanup alternative specified in the Record of Decision (dated September 30, 1999) is being implemented under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA).

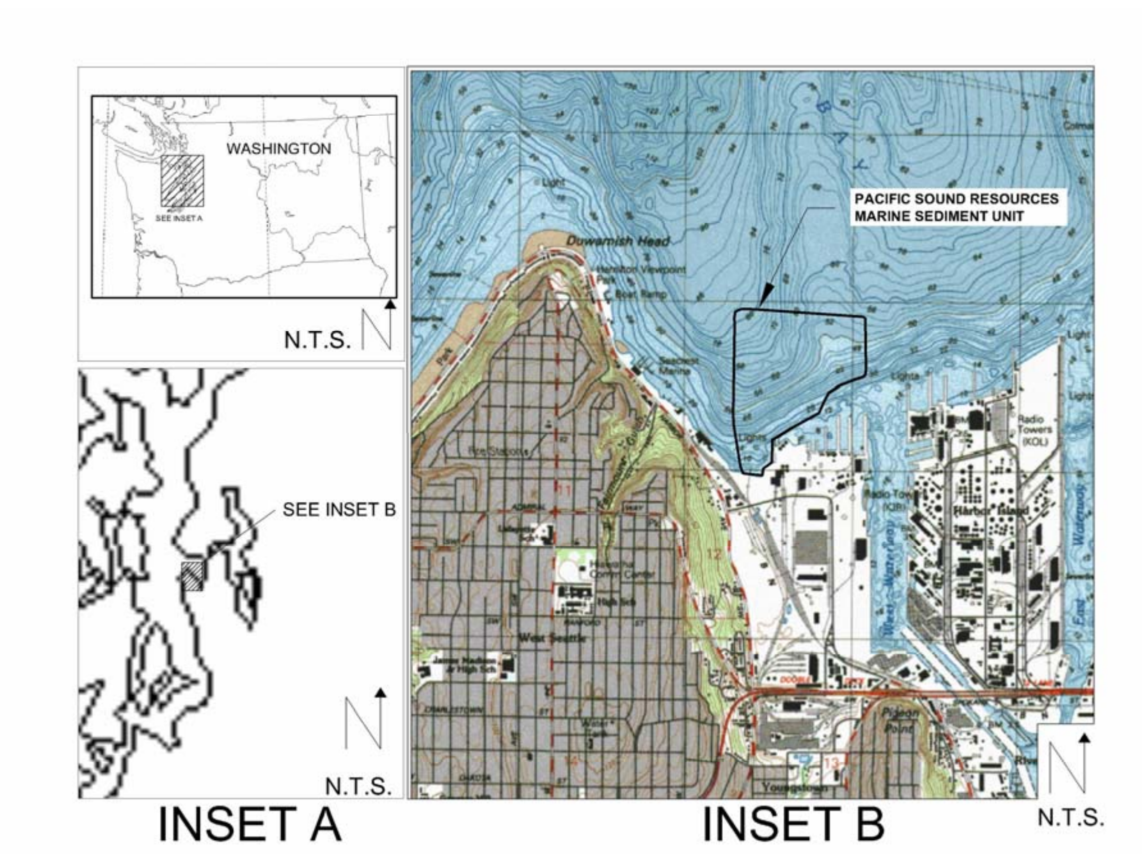

Figure 1 Vicinity Map

The MSU was contaminated by creosote and wood-treating chemicals from historical wood-treating operations on the upland portion of the site. Primary chemicals of concern in the MSU are polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs). PAHs were detected in excess of the screening level in sediments collected from as deep as 20 feet below the mudline. Lateral and downgradient migration of nonaqueous-phase liquids (NAPLs), transport of contaminated groundwater, and erosion of impacted soils by stormwater runoff from the Upland Unit represent additional sources and transport mechanisms to the MSU.

The MSU was subdivided into remediation areas according to specific site conditions, including operational conditions that affect remedy implementation. As part of the remediation effort, work was performed in six of these areas during the 2003/2004 and 2004/2005 in-water construction seasons. Capping, dredging, and other in-water construction activities were performed by American Civil Constructors-West Coast (ACC), under contract to the U.S. Army Corps of Engineers (USACE). A sediment cap was placed in four of the remediation areas. Dredging was performed to maintain navigation depths in one of the remediation areas.

Blasland, Bouck & Lee, Inc. (BBL) performed water-quality monitoring during the 2003/2004 and 2004/2005 in-water activities, which included placement of the engineered sediment cap. The objective of the water quality monitoring was to assess potential short-term water quality impacts from capping and associated in-water construction activities and to invoke corrective actions, if necessary, to bring construction activities into compliance with water quality criteria.

WATER QUALITY MONITORING METHODS

The water quality monitoring was performed in general accordance with the *Water Quality Monitoring Sampling and Analysis Plan* (BBL, 2003a), the *Water Quality Monitoring Plan, Field Sampling Plan/Quality Assurance Project Plan* (BBL, 2003b), the Technical Specifications (USACE, 2003), and the Water Quality Certification (U.S. Environmental Protection Agency [USEPA], 2003a, 2003b).

Specific objectives of the water-quality monitoring program included the following:

- Document ambient conditions prior to construction activities and water quality conditions during construction activities.
- Assess water-quality parameters (dissolved oxygen [DO], turbidity, and temperature) in the vicinity of in-water activities for comparison to the limits prescribed in the Water Quality Certification.
- Guide ACC to modify construction operations, as necessary, to protect the receiving water environment.
- Provide continuous visual monitoring during construction for the presence of oily sediment, sheen, and any distressed or dying fish or wildlife.

Compliance boundaries were established during construction on a mixing zone radius of 300 feet for dredging activities and 600 feet for capping activities. The mixing zones were oriented radially around each construction activity and migrated with the activity. Monitoring was performed at the water quality compliance boundary at the edge of the mixing zone (Figure 2). In addition, DO was monitored at an “early warning” location at the midpoint of the radius of the mixing zone. Three down-current locations (Early Warning, Downgradient 1, and Downgradient 2) and one up-current location (Upgradient) were monitored. The Early Warning station was monitored for compliance with DO criteria; however, this location was not a point of compliance for any other water quality criteria.

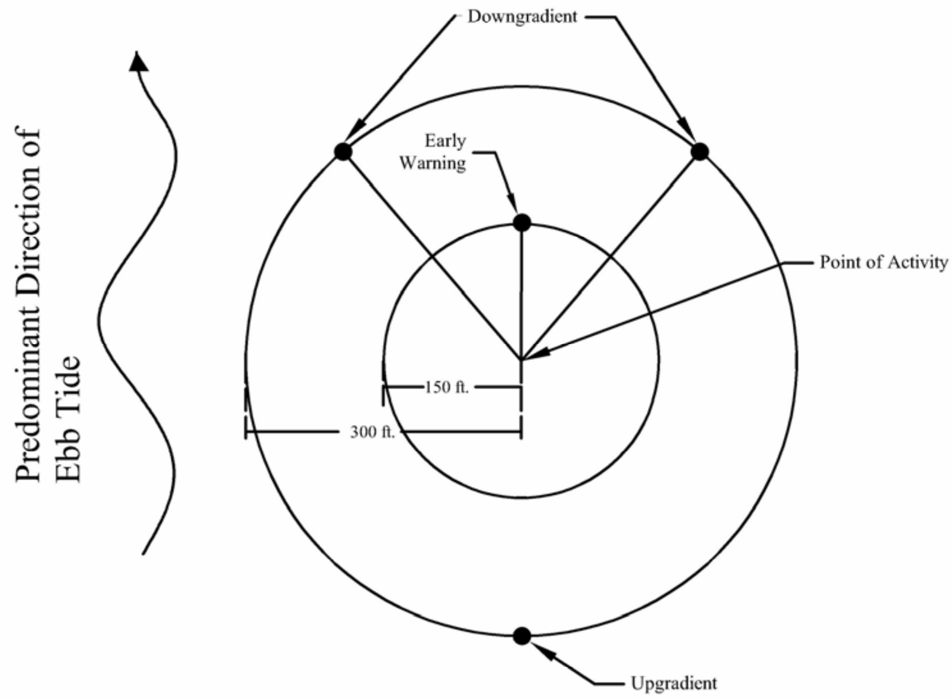

Figure 2 Compliance Water Quality Monitoring Locations During Dredging

Water quality monitoring was performed according to three schedules: intensive, routine, and limited. Intensive monitoring was conducted during the startup of in-water construction activities and in response to any major modifications to construction procedures or exceedances of water quality criteria. Routine water quality monitoring was conducted when no exceedances of water quality criteria were recorded for a minimum of 2 days. Limited water quality monitoring was initiated when no exceedances of water quality criteria were observed for a minimum of 1 week. Continuous visual monitoring was also conducted during all work activities. Ambient monitoring was performed at reference stations in conjunction with the compliance monitoring under all three schedules and before construction activities commenced.

The following water quality parameters were monitored in the vicinity of each in-water activity:

- DO;
- turbidity;
- temperature; and
- total suspended solids (TSS).

DO, turbidity, and temperature were measured at three water depths: shallow, intermediate, and deep portions of the water column. The shallow depth was 3 feet below the surface of the water, the intermediate depth was the midpoint of the water column, and the deep depth was 3 feet above the mudline. DO, turbidity, and temperature were measured in situ with a YSI 6920 multi-meter probe at the following stations: Reference 1, Reference 2, Reference 3, Early Warning, Downgradient 1, Downgradient 2, and Upgradient.

Samples for TSS analysis were collected only from the intermediate portion of the water column using a van Dorn water sampler. TSS samples were analyzed on a 5-day turn-around time schedule. TSS samples were collected at the following stations: Reference 1, Reference 2, Reference 3, Downgradient 1, Downgradient 2, and Upgradient.

No TSS samples were required or collected at the Early Warning station. There were no water quality criteria for TSS; it was collected for informational purposes only.

In addition to the water quality monitoring described above, the water surface was continually monitored during all work activities for sheens and distressed fish or wildlife, except when nightfall made these observations impossible. When BBL was not on the water performing water quality monitoring, ACC performed the continual monitoring for sheens and distressed fish or wildlife.

The Water Quality Certification states that dredging and other in-water activities must meet Water Quality Standards for Surface Waters of the State of Washington (Washington Administrative Code [WAC] 173-201A), a delegated state authority for the Clean Water Act (CWA) regulation. In addition, dredging and other in-water activities must meet the conditions of the Water Quality Certification.

The MSU is situated in Class A waters of the state of Washington, per WAC 173-201A. Water quality compliance criteria are specified in WAC 173-201A for Class A waters and in the Water Quality Certification. In accordance with the Water Quality Certification, compliance was determined at the boundary of the dilution zone (referred to as a "mixing zone" in this report) by comparing water quality measurements to the performance criteria.

Compliance measurements were made against a 30-day running average of reference station data, as determined from all depth strata across all reference stations. When it appeared that a given water quality measurement was outside the bounds of the 30-day running average (i.e., higher or lower, depending on the criterion), that data point was compared to the daily reference average for the particular depth stratum in question. For example, if the turbidity measurement in the deep sample from the Downgradient 1 station on any particular day was greater than the 30-day running average, that deep turbidity reading was compared to the average of the three deep turbidity readings from the reference stations for that day.

In addition, DO monitoring at the midpoint of the mixing zone (Early Warning station) was evaluated for compliance with the acute effects DO criteria listed in the Water Quality Certification. This midpoint location was not used to determine compliance with any other parameters.

BACKGROUND WATER QUALITY

Water quality compliance for this project was determined by comparing water quality compliance monitoring results to background water quality. Measurements of background water quality began prior to the initiation of construction each year and continued through the in-water construction season. Background water quality was evaluated at three fixed reference stations. The reference stations were located outside the influence of construction activities.

Background water quality was measured twice daily for 3 days before the start of each in-water construction season. Establishing valid background water quality was crucial to the success of the project. Water quality monitoring during construction indicated that water quality exceedances were rarely associated with construction activities. Rather, temporary fluctuations in water quality appeared to be related to general background conditions, such as tidal surge, current fluctuation, and wave action that impacted water quality. Collecting sufficient background water quality to enable these evaluations allowed the construction work to continue.

DREDGING WATER QUALITY

Dredging occurred for approximately 1 month in September and October 2003. Dredging was performed in the vicinity of the dock onsite to allow for adequate water depth for vessels once the cap was placed. Dredging was completed with a 4-cubic-yard environmental bucket in water depths ranging from about -3 to -35 feet mean lower low water (MLLW). Approximately 9,750 cubic yards of material was dredged. Dredged material was placed in barges, transported offsite, unloaded, and disposed of in a landfill in eastern Washington. Based on a pre-dredging composite sample, dredged material consisted of a silty sand material (SM) of sand (71%) with some silt (23%), trace clay (5%), and gravel (1%). The composite sample was granular and non-plastic with a moisture content of 27%. There was an overdredge allowance of 1 foot.

Water quality monitoring was performed during dredging. Water quality monitoring results were within compliance criteria, except for one turbidity result. Turbidity results during dredging are presented on Figure 3. One turbidity result was above the compliance criterion by about 2 nephelometric turbidity units (NTU). Adjacent sampling locations were within the compliance criterion. The temporary turbidity exceedance at one location appears to be a result of local background water conditions, possibly associated with the high tide that occurred during the sampling time.

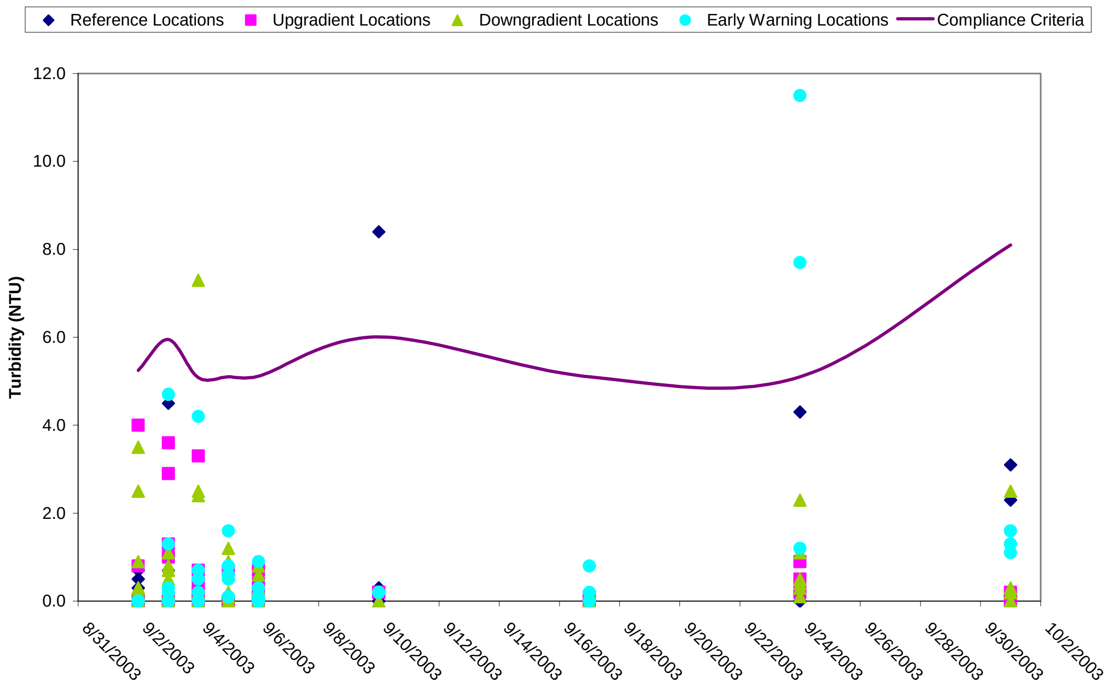

Figure 3 Turbidity Versus Time During Dredging

Turbidity results varied with depth, as shown on Figure 4. This figure shows turbidity versus sampling depth: shallow (3 feet below the surface), intermediate (middle of water column), or deep (3 feet off the mudline) sample depth. There is limited variability in shallow samples. All results are less than 2 NTU and represent clear water. There is slightly more variability with intermediate samples. All results are below 3 NTU, except for one Early Warning location that contained a turbidity of 7.7 NTU. The Early Warning locations were not subject to the turbidity criteria. The deep samples had the largest variability, with turbidity ranging from 0 to 8.4 NTU. This variability may be a result of general background conditions, such as tidal surge, current fluctuation, and wave action that resuspended sediment and raised turbidity. It may also be related to the construction activity. Water quality impacts during dredging with an environmental bucket have typically appeared in deep samples at other projects. As the clamshell bites into the sediment, particles can be resuspended. However, the environmental clamshell bucket tends to allow little resuspension as the bucket is raised through the water column.

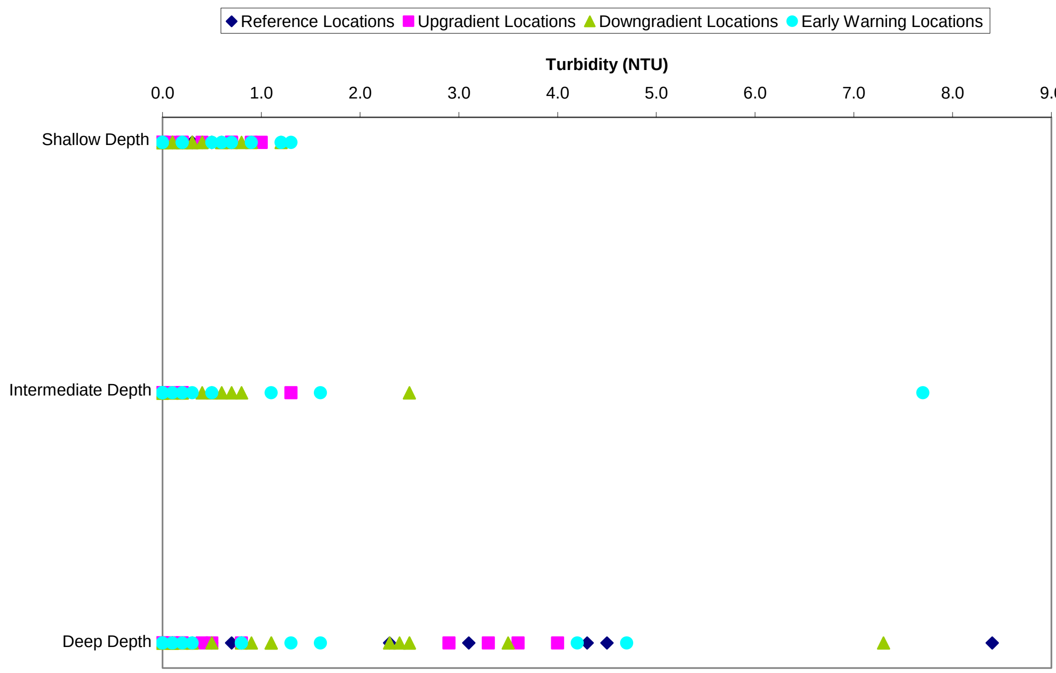

Figure 5 Turbidity Versus Sampling Depth During Dredging

Temperature and DO results during dredging never exceeded water quality criteria as a result of construction activities. Temperature results above the temperature criteria were observed only during summer months when compliance stations had temperature results similar to those of background stations. DO results were also associated with seasonal fluctuations in the background water. During summer months and sunny days, higher DO was observed in shallow samples than in intermediate and deep samples, at all locations.

A correlation between turbidity and TSS results was not observed during dredging. TSS results tended to be low or not detected. Turbidity results also tended to be low. Given the low and at-detection-limit results for TSS and turbidity, a correlation between the two was not observed.

The water quality monitoring results during dredging illustrate the importance of collecting adequate background water quality data. By collecting weekly background water quality data, we were able to track changes in background water quality and to associate compliance water quality results with these changes in background conditions. It also illustrates the value of close communication between the water quality monitoring company, the contractor, and the client. Receiving notification of water quality monitoring results and preliminary interpretations at the end of the day allowed ACC to make an informed decision on operations and to keep the USACE apprised of the situation.

CAPPING

This section presents a discussion of water quality monitoring during capping with different construction equipment and different cap material.

Skiff Box Capping

Capping by skiff box was conducted for approximately 5 months, from October 2003 through February 2004. Capping was completed with a 6- by 12- by 2.5-foot-deep skiff box in water depths ranging from about 0 to -35 feet MLLW. Practically, the skiff box held about 5 cubic yards of material during each cycle. Capping was performed by lowering the skiff box to within 3 feet of the mudline, opening the flaps on the box, and releasing cap material. Five types of cap material were placed with the skiff box:

- gravel mix: well-graded gravel (GW) with gravel (85%) and little sand (15%) – about 34,000 tons of material;
- habitat mix: gravel sand mixture (GC) with gravel (50%), sand (40%), and trace silt (10%) – about 3,000 tons of material;
- sand cap mix: gravelly sands (SW) with sand (80%), little gravel (10%), and trace silt (10%) – 28,000 tons of material;
- riprap: individual pieces weighing from 50 to 1,000 pounds – about 11,000 tons of material; and
- filter material no. 2: well-graded gravel (GW) with gravel (85%), trace sand (10%), and silt (5%) – about 2,700 tons of material.

Cap thickness ranged from about 4 to 7 feet thick. Cap was placed on relatively flat areas and on areas with slopes of about 2:1.

Water quality monitoring was performed during capping with the skiff box. Water quality monitoring results were within compliance criteria, except for one turbidity result. Turbidity results during capping with the skiff box are presented on Figure 5. One turbidity result was above the compliance criterion by about 1 NTU. Adjacent sampling locations were within the compliance criterion. The temporary exceedance at one location appears to be a result of local background water conditions, possibly associated with the low tide that occurred during the sampling time.

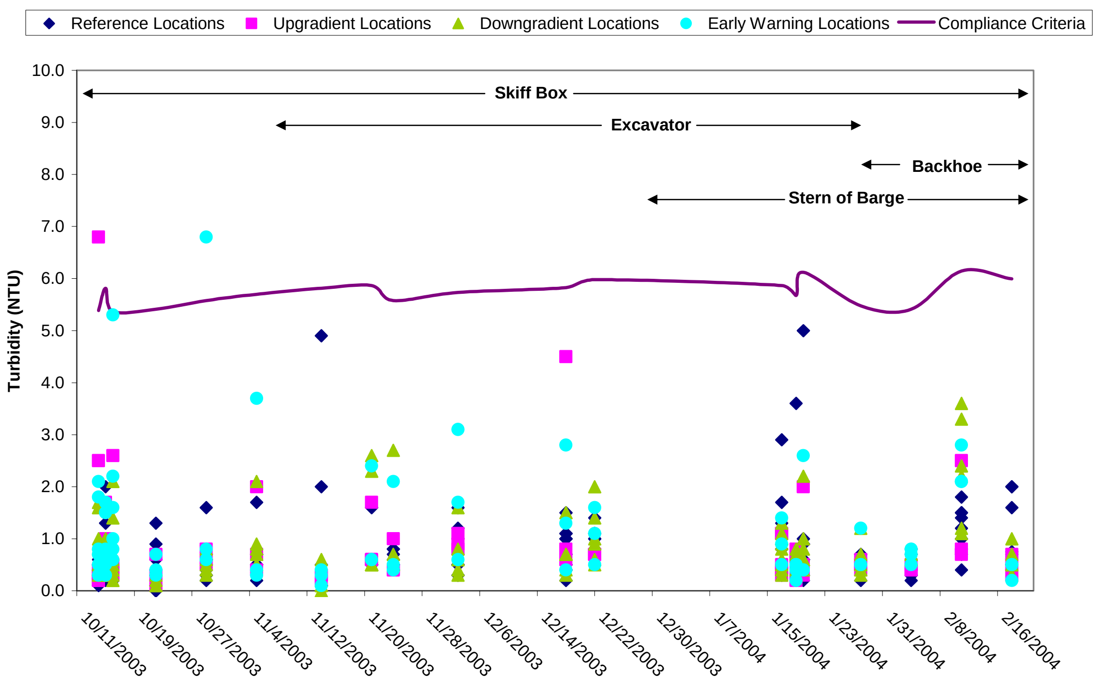

Figure 6 Turbidity Versus Time During Capping 2003/2004

Excavator Capping

Capping by Cat 375 excavator with a 2.5-cubic-yard clamshell bucket from a barge was conducted for approximately 3 months, from November 2003 through January 2004. Capping was completed in water depths ranging from about 0 to -25 feet MLLW. Capping was performed by scooping cap material from a barge into the bucket, moving the bucket arm over the water, and releasing the capping material at the water surface. Three types of material were placed with the excavator:

- gravel mix: well-graded gravel (GW) with gravel (85%) and little sand (15%) – small amount of material;
- sand cap: gravelly sands (SW) with sand (80%), little gravel (10%), and trace silt (10%) – about 16,000 tons of material; and

- dredged material from the Duwamish River – small amount of material.

Cap was about 2 feet thick and was placed on relatively flat areas.

Water quality monitoring was performed during capping with the excavator. Water quality monitoring results were within compliance criteria during capping with the excavator. Turbidity results during capping with the excavator are presented on Figure 5.

Backhoe Capping

Capping was performed by transferring cap material from a barge to shore using a conveyor belt. Material on shore was then distributed during low tide, in the dry, with a backhoe. Backhoe capping was conducted for approximately 1 month, in February 2004. Beach sand, a silty sand (SM) with sand (90%) with trace silt (10%), was placed by this method. Approximately 700 tons of material were placed by this method.

Cap was about 1 foot thick and was placed on relatively flat areas.

Water quality monitoring was not specifically performed during capping from shore because capping was done in the dry during low tide. Water quality impacts were not expected while capping in the dry. However, water quality monitoring was performed during transfer of cap material from the barge to the shore as the cap material was transferred into shallow water near shore. Water quality monitoring results were within compliance criteria during the transfer of cap material. Turbidity results during the transfer of cap material are presented on Figure 5.

Stern of Barge Capping

Capping was performed by pushing cap material over the stern of the barge using conventional earth moving equipment. This took place for approximately 2 months, in January and February 2004. Capping was completed in water depths ranging from about -145 to -200 feet MLLW. Approximately 18,000 cubic yards of dredged material from the Duwamish River were placed..

Cap ranged from 3 to 4 feet thick and was placed on relatively flat areas.

Water quality monitoring was performed during capping over the stern of the barge. Water quality monitoring results were within compliance criteria. Turbidity results during capping over the barge stern are presented on Figure 5.

Summary of Water Quality During Capping 2003/2004

Water quality monitoring during capping in construction year 2003/2004 had one turbidity result that exceeded the compliance criterion by approximately 1 NTU. This turbidity was measured during capping by skiff box. Adjacent sampling locations were within the compliance criterion. The temporary exceedance at one location appears to be a result of local background water conditions, possibly associated with the low tide that occurred during the sampling activities. Water quality appeared to temporarily fluctuate as a result of general background conditions, such as tidal surge, current fluctuation, and wave action.

Turbidity results varied with water depth during capping in construction year 2003/2004, as shown on Figure 6. This figure shows turbidity versus sampling depth: shallow (3 feet below the surface), intermediate (middle of water column), or deep (3 feet off the mudline) sample depth. Shallow and deep samples had more variability than intermediate samples. Turbidity ranged from 0 to approximately 5 NTU in shallow samples. All intermediate results were below 3 NTU, except for one Early Warning location that contained a turbidity of 6.8 NTU. The Early Warning locations were not subject to the turbidity criteria. The deep samples had more variability than the intermediate samples but less variability than the shallow samples.

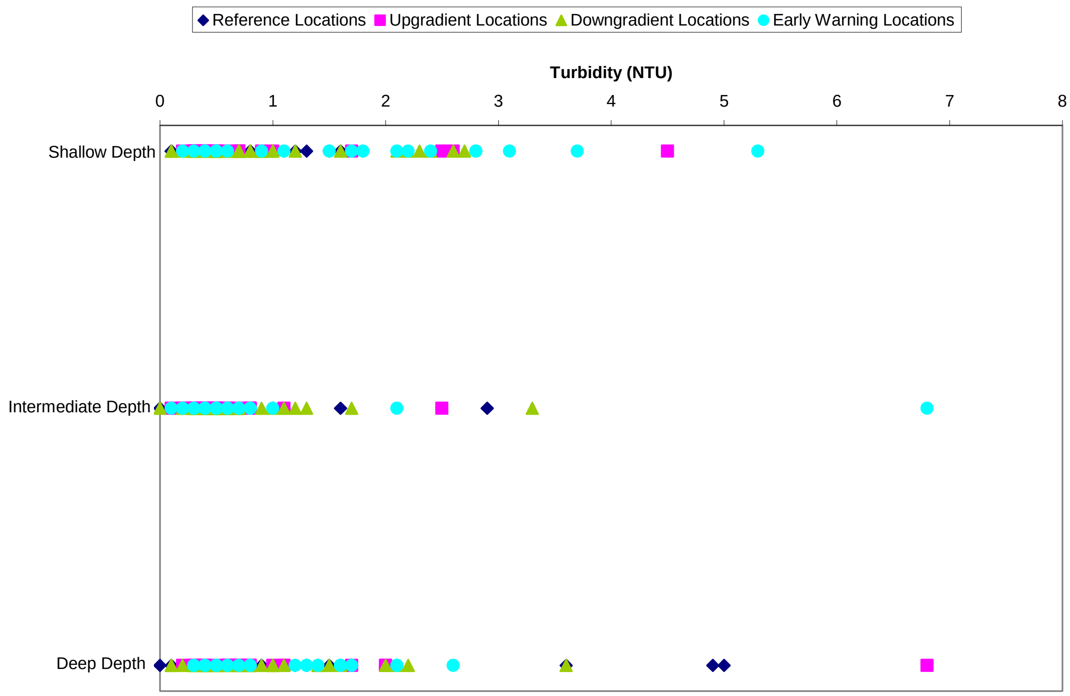

Figure 7 Turbidity Versus Sampling Depth During Capping 2003/2004

This variability may be a result of general background conditions, such as tidal surge, current fluctuation, and wave action that resuspended sediment and raised turbidity. During high tide, surface-water debris was observed to migrate from the bay into the project site. During slack tides, temporary spikes in turbidity were observed at deep sampling depths at some locations. The variability in turbidity with depth may also be related to the construction activities. Fluctuations in turbidity during capping with a skiff box, excavator, and from the stern of the barge would be expected in deep and shallow samples. When the bucket or excavator is lowered into the water or when the cap material is pushed over the stern of the barge, there could be a release of fines in surface water that may appear in the turbidity results. As the cap material impacts the sediment, sediment could be resuspended, which may be seen in the turbidity results. Although capping activities during the 2003/2004 construction year may have contributed to the observed variability in turbidity with depth, construction activities did not result in exceedances of water quality criteria.

Bottom Dump Barge Capping

Capping was also performed by bottom dump barge. The barge contained six compartments and had a capacity of about 2,500 tons. Bottom dump barge capping was conducted for approximately 3 months, from September through November 2004. Capping was completed in water depths ranging from about -15 to -145 feet MLLW. Gravel mix placed by this method was a well-graded gravel (GW) with gravel (85%) and little sand (15%). Approximately 250,000 tons of material were placed by this method.

Cap thickness ranged from 3 to 4 feet and was placed on relatively flat areas.

Water quality monitoring was performed during capping by bottom dump barge. Water quality monitoring results were within compliance criteria, except for a number of turbidity results. Turbidity results during bottom dump barge capping are presented on Figure 7. Maximum turbidity exceedances were about 10 NTU above the compliance criterion. Turbidity results above the compliance criteria generally occurred in Downgradient samples from the deep depth. These exceedances usually occurred at one Downgradient location but were not observed at the adjacent Downgradient location during a sampling event. Based on the spatial and temporal trends in the data, the data do not appear to indicate that project-related activities were responsible for the observed deviations of the compliance criteria in the turbidity data. If the temporary spikes in turbidity were associated with construction activities, it would be expected that they would be observed in the Early Warning and two Downgradient locations. These exceedances were never observed at all three locations at once. Occasionally (3 of 7 days when exceedances were observed), exceedances were observed in both Downgradient locations but not in the Early Warning location. Also, if exceedances were a result of capping activities (from placing approximately 2,500 tons of gravel from a bottom dump barge in about 2 minutes), it would be reasonable to expect turbidity higher than about 15 NTU, which was the maximum exceedance observed. Temporary turbidity spikes were also occasionally observed at Reference Station 3 in the deep sample. The data indicate that momentary spikes in turbidity observed throughout the construction area may be more indicative of general background conditions, such as tidal surge, current fluctuation, and wave action.

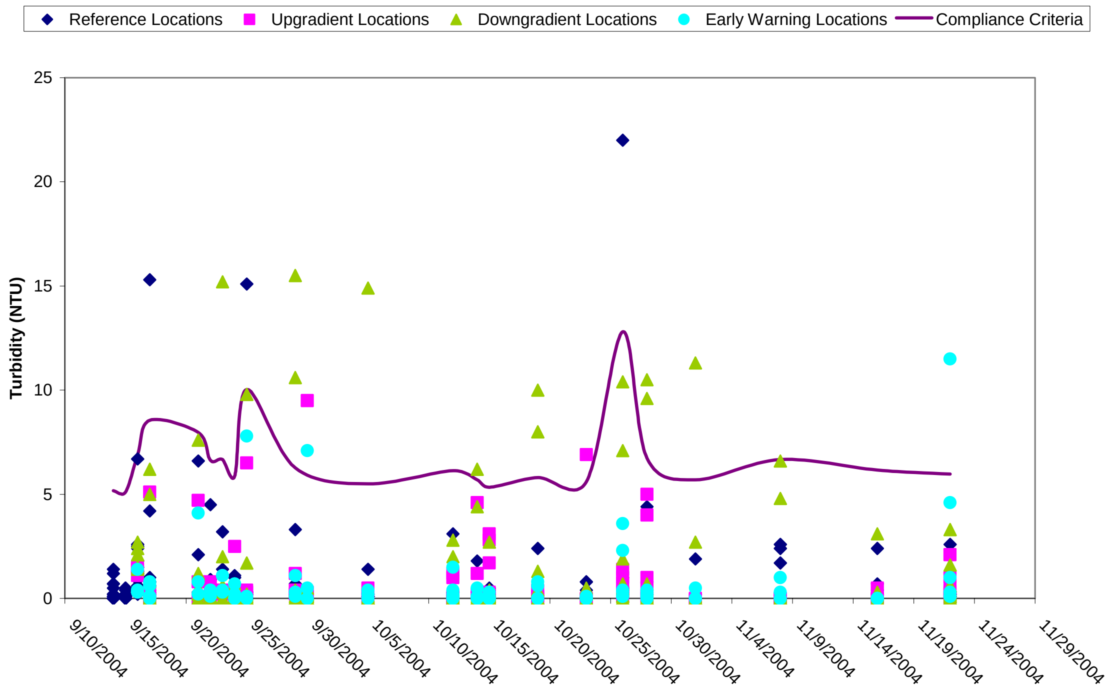

Figure 8 Turbidity Versus Time During Capping 2004/2005

To confirm the theory that temporary turbidity spikes were a result of general background conditions rather than construction activities, monitoring was performed at Reference Station 3 for 2 hours, beginning at a low slack tide and continuing into a flood tide. A barge of material was placed during the monitoring period, and monitoring continued for approximately 1½ hours after placement. Monitoring was performed continuously at the deep depth. Turbidity remained below 7 NTU, except for one measurement of about 13 NTU when a large wave rocked the sampling vessel and appeared to temporarily raise the turbidity. After cap placement, turbidity remained below 5 NTU. This monitoring exercise supported the theory that temporary rises in turbidity appeared to be the result of general background water quality conditions rather than construction impacts.

Turbidity results varied with depth, as shown on Figure 8. This figure shows turbidity versus sampling depth: shallow (3 feet below the surface), intermediate (middle of water column), or deep (3 feet off the mudline) sample depth. The deep samples had more variability than the shallow and intermediate samples. The intermediate samples had more variability than the shallow samples. This variability may be a result of general background conditions, such as tidal surge, current fluctuation, and wave action, that resuspended sediment and raised turbidity. It may also be related to construction activity. Water quality impacts during capping with a bottom dump barge typically appear in intermediate and deep samples. The cap material is released about 7 feet below the surface of the water. There is not an opportunity for cap material to come into contact with surface water and produce surface turbidity. As the cap material falls through the water column, there may be a release of fines in intermediate water depths that may appear in the turbidity results. As the cap material impacts the sediment, sediment is resuspended and may be seen in the turbidity results. Although bottom dump barge capping may have contributed to the observed variability in turbidity with depth, construction activities did not result in exceedances of water quality criteria.

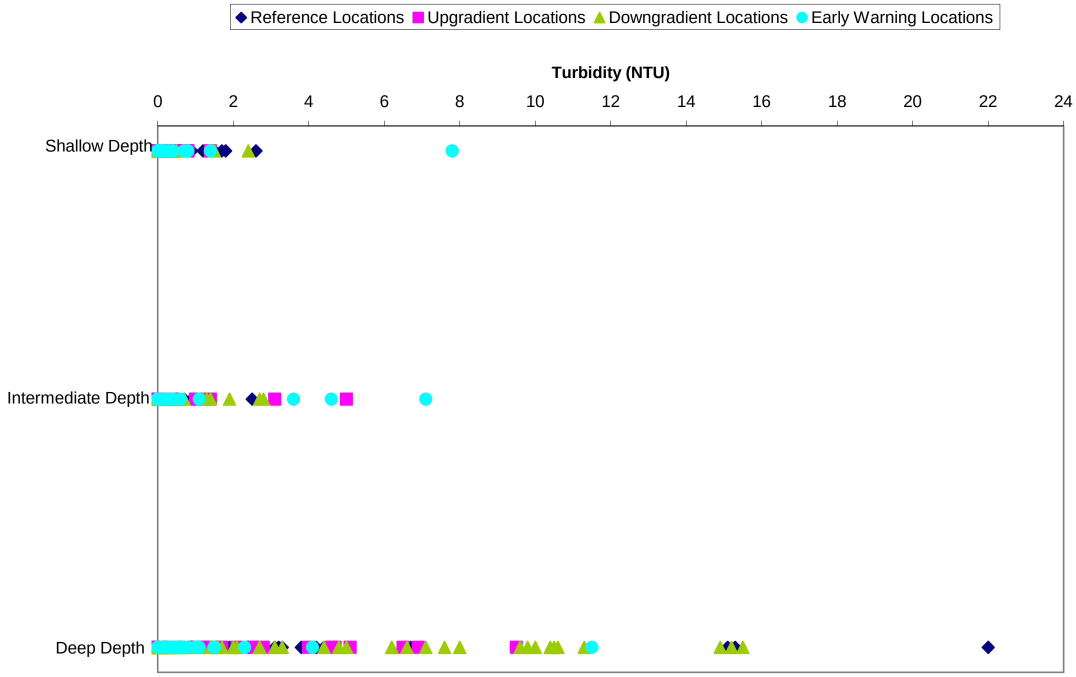

Figure 9 Turbidity Versus Sampling Depth During Capping 2004/2005

Other Water Quality Results During Capping

Temperature and DO results during capping never exceeded water quality criteria as a result of construction activities. Temperature results above the temperature criteria were observed only during summer months when compliance stations had temperature results similar to those of background stations. DO results were also associated with seasonal fluctuations in the water column. During summer months and sunny days, higher DO was observed in shallow samples than in intermediate and deep samples, at all locations.

A correlation between turbidity and TSS results was not observed during capping. TSS results tended to be low or not detected. Turbidity results also tended to be low. Given the low and at-detection-limit results for TSS and turbidity, a correlation between the two was not observed.

CONCLUSIONS

Water quality monitoring results during dredging and capping at the Pacific Sound Resources Superfund Site revealed occasional turbidity exceedances of the water quality criteria. Temperature and DO criteria were not impacted by construction activities. Temporary and slight exceedances of the turbidity water quality criteria appeared to be a result of background fluctuations in water quality, possibly associated with tidal surge, current fluctuation, or wave action. Construction activities did not appear to impact water quality by resulting in water quality exceedances.

The weekly monitoring of background water quality during the two in-water construction years allowed background water quality changes to be tracked and compared to compliance water quality results. This allowed construction work to continue without costly work stoppages. Close communication between BBL, ACC, and the USACE permitted successful completion of the work. Receiving notification of water quality monitoring results and preliminary interpretations at the end of the day allowed ACC to make informed decisions regarding operations and kept the USACE apprised of water quality criteria.

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