A STICK IN THE MUD: U.S. COAST GUARD, SLIP 36 DREDGING AND REBUILD, SEATTLE, WASHINGTON

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ABSTRACT

A construction project on the Seattle Washington waterfront during the fall 2004 dredging season succeeded as a result of the willingness of the project proponent, the US Coast Guard, to work collaboratively with state and federal agencies when the project didn't proceed as planned. The project, involving dredging of both clean and contaminated sediments and replacement of a creosote-treated pier, also illustrated the Dredged Material Management Program's ability to adapt to new technical and management challenges, and offers several lessons for dredgers, consultants, and regulators.

This project demonstrates several lessons including: understanding and improving upon the limits of existing testing methods; how to address unanticipated contamination; the importance of monitoring the dredging process; and the significant advantages of collaborative interagency relationships.

Keywords: Dredging, dredged material disposal, contaminated sediment, piling removal, sediment testing, Dredged Material Management Program (DMMP).

INTRODUCTION

The interagency Dredged Material Management Program (DMMP), jointly administered by the U.S. Army Corps of Engineers (Corps), U.S. Environmental Protection Agency (EPA), and Washington Departments of Ecology (Ecology) and Natural Resources (DNR), is responsible for managing dredged material throughout Puget Sound and the coastal estuaries in Washington state. The DMMP enjoys international recognition for nearly two successful decades of adaptive management that protects the aquatic environment while minimizing dredging project costs through a predictable, consistent, and efficient regulatory process.

The U.S. Coast Guard's (USCG) Slip 36 facility provides berthing for several ice breakers and frigates. The USCG planned to replace a degraded wooden pier with a narrower and more environmentally friendly concrete structure in order to provide greater navigational depth and additional space to streamline ship movement within the facility. The project included of multiple construction and dredging phases, including: replacement of the original creosote-treated wooden pier with the new concrete structure; dredging contaminated surface sediments within and adjacent to the footprint of the original structure; construction of subsurface gravel columns to stabilize the footing of the new pier; and dredging clean sediments down to final project depth. The project seemed to proceed smoothly until the gravel column installation phase, during which an unanticipated oily sheen surfaced on the water.

Working collaboratively, the USCG and DMMP agencies investigated the source of the sheen. Initial investigations suggested two most-probable hypotheses: unsuitable sediments that the dredging contractor did not remove earlier, and creosote from the original wooden pilings. The DMMP agencies and USCG devised a tiered testing approach consisting of visual examination, surface sediment grabs, and sediment cores. This approach ultimately suggested that both hypotheses were true. While no sediments in the immediate area proved suitable for open water disposal, the adaptive testing approach protected the aquatic environment and saved the USCG significant natural resource damage costs. This paper addresses the lessons learned through the cooperation between the USCG and the DMMP agencies during the dredging and gravel column installation components of the Pier 36 construction project.

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DISCUSSION

To improve berthing and navigation at their Slip 36 facility on the Seattle waterfront, the U.S. Coast Guard (USCG) removed an old, creosote-treated, wooden pier, which they replaced with a smaller, concrete pier. The new pier, built to significantly higher environmental standards, occupied a smaller footprint than the original structure to provide more space to improve ship maneuverability and allow for greater berthing flexibility on site. The USCG also dredged roughly 50,000 cubic yards of sediments to provide sufficient navigational depth for several ice breakers stationed at the facility.

The USCG planned the construction sequence to best protect the aquatic ecosystem. The USCG project may be summarized in a sequence of six fundamental components: sediment testing, pier removal, new pier construction, dredging of sediments unsuitable for open water disposal, gravel column construction, and dredging of sediments suitable for open water disposal. As part of the initial project planning and approval, the USCG tested the sediments to be dredged according to Puget Sound Dredged Disposal Analysis (PSDDA) protocols to determine what disposal options would be available for the sediments, including those beneath the footprint of the old, wooden pier. Interpretation of sediment test data showed sediment characteristics that are typical for this part of the Seattle waterfront. Some surface Dredged Material Management Units (DMMUs) failed PSDDA suitability criteria for open water disposal, however subsurface DMMUs tended to meet these criteria. Following sediment testing, the USCG demolished the old pier and removed as many of the remnant pilings as was technically feasible. Next they completed construction of the replacement pier. The USCG planned to conduct dredging in two discrete phases interrupted by the installation of subsurface gravel columns, which were placed to stabilize the footing of the new pier. The USCG sequenced these final three project components to protect against the spread of surface contaminants.

The project proceeded generally according to plan through the dredging of unsuitable surface sediments. After the USCG's dredging contractor reported unsuitable sediment dredging complete, they initiated construction of the subsurface gravel columns. The sediments in this area are characterized by very low shear strength and are subject to liquefaction in the event of an earthquake. The gravel columns are the primary support for an underwater sheet-pile wall, which in turn supports the footings of the newly constructed pier. The gravel columns densify the sediments adjacent to the underwater sheet-pile wall and are required to stabilize this area such that it can withstand shear loading from the weight of the new pier during a seismic event. Installation of the gravel columns involves forcing a probe deep into the sediments adjacent to the new pier, through which gravel is injected under high pressure [Figure 1]. The probe is set initially at the target depth and withdrawn vertically as gravel is injected to form a column. The probe is also used to pack gravel more densely as it is injected into the sediments. The net result is a dramatic increase in overall sediment shear strength.

Figure 1: This is an extra head for the gravel column construction probe, which was stored temporarily on the new pier. Note the large, angled pipe pointing toward the center of the probe. Gravel is injected into the sediments through this pipe. Both air and water are forced through the smaller pipes on either side of the probe to scour material from beneath the probe head as needed.

The gravel column construction process sends significant vibrations through the sediment substrate. These vibrations propagate to sediments well outside of the immediate work vicinity, as noted by observers of bubble columns rising to the surface a distance on the order of 100 feet from immediate construction activities [Figures 2 and 3]. Presumably, these bubbles are mobilized from low-density voids in the sediments left behind following piling removal.

Figure 2: Gravel column construction is underway, as gravel is injected deep into the sediments. Note the water disturbance in the immediate vicinity of the probe.

Figure 3: Columns of air bubbles mobilized from the sediments are rising to the water surface during and immediately following construction. [Insert is a close up of the rising bubble columns.]

During the gravel column installation phase of construction, USCG observers noted a significant sheen rising to the surface in the immediate construction areas, with lesser sheens rising with the bubble columns further from immediate construction activities. The USCG immediately contained the sheen and notified the DMMP agencies [Figure 4].

Figure 4: Creosote sheen rising from the sediments is contained by boom.

The USCG and DMMP agencies initially considered one hypothesis to explain the source of the sheen. Hypothesis 1: The initial PSDDA sediment screening process did not accurately characterize the sediments and creosote residuals remaining after the old wooden pilings were being remobilized into the water column by the vibrations of gravel column installation.

The USCG and DMMP devised a tiered testing strategy to examine the source and extent of chemicals causing the sheen. The first tier of testing involved collecting 10 to 12 grabs of surface sediments to 1) visually examine the sediment samples for the presence of creosote and/or sheen, and 2) submit four sediment samples in the construction areas of greatest sheen production to test for polycyclic aromatic hydrocarbons (PAHs). If both visual and chemical analysis results came back clean, project construction could resume as planned. However, vibracore sampling would be required if analysis of the surface grabs showed elevated levels of creosote in the sediments previously characterized as "suitable."

Sampling locations, as initially proposed, had to be modified to accommodate construction barges on site, however the DMMP agencies subsequently approved the modified plan to collect eight surface grabs identified as "SS-1" through "SS-8" [Figure 5]. In all of the samples collected observers noted moderate to heavy sheens. The USCG submitted four of these samples for PAH-analyses (SS-2, SS-4, SS-6 and SS-7). PAHs were detected in all samples analyzed, and one or more PAHs exceeding DMMP Screening Levels (SL) were detected in samples SS-2, SS-4 and SS-6. Basing their decision upon both the visual and chemical analyses, the USCG and DMMP agencies agreed that the surface sediments were unsuitable for open water disposal.

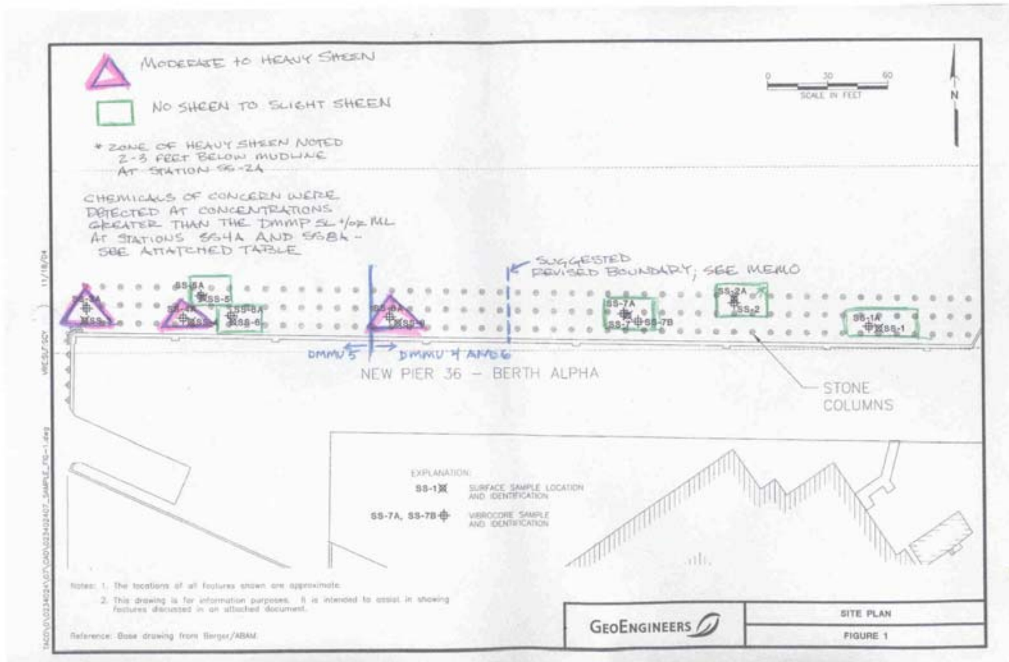

Figure 5. Sampling location schematic.

While surface grabs were being analyzed, however, the USCG reviewed data from post-dredge surveys performed after the dredging contractor reported removal of DMMP-unsuitable material complete. This subsequent examination showed that the dredging contractor had not removed all unsuitable sediments as required under the approved project plan, leaving between 1 to 5 feet (vertical thickness) of unsuitable material in place. This discovery introduced a second hypothesis. Hypothesis 2: Gravel column construction activities remobilized unsuitable sediments remaining on site, contributing to the sheen observed during construction and potentially contaminating the surrounding surface sediments.

Following the discovery of unsuitable materials from post-dredge survey results, the USCG and DMMP agencies agreed to a new course of action in the area of concern. Requiring best management practices to minimize and contain the sheen, the USCG and DMMP agencies agreed to allow completion of the gravel column construction phase. Following completion of gravel column construction, the USCG and DMMP agencies required the dredging contractor to survey post-column construction bathymetry and perform any additional dredging required to achieve design grade and remove remaining material previously characterized as unsuitable. Given the project record, the DMMP agencies required another bathymetric survey after the additional dredging to verify removal of all unsuitable material in accordance with original project plans. This final survey following the second pass of dredging showed several “high spots” of unsuitable material remaining. The USCG and DMMP agencies required the dredging contractor to remove these sediments prior to dredging any material subsequently confirmed to be suitable for open water disposal.

To address both hypotheses, the USCG decided to collect 4-foot deep (minimum) vibracore sediment samples in roughly the same location where the previous eight grab samples had been collected. Corresponding to the naming convention of the eight previous surface grab samples, the eight cores were identified as “SS-1A” through “SS-8A”. At station “SS-7A” a second core, identified as “SS7-B”, was collected when the initial core encountered a remnant pile in the subsurface. The USCG decided to adopt a tiered approach to interpreting the core data. Each core was examined visually to detect the extent of sheen present in the sediment column. Depths at which sheen was observed were deemed unsuitable for open water disposal. Although the initial plan was to analyze only those sections of the cores without observable sheen, the USCG later modified this plan to accommodate testing requirements from the upland disposal facility. Cores were divided into upper and lower sections, and samples from four of these sectioned cores were submitted for PAH analysis (SS-1A, SS-4A, SS-7A and B, and SS-8A). The USCG planned to modify the final dredging plan to accommodate the results from these analyses.

Visually inspection [Figure 6] of the cores revealed moderate to heavy sheen on the upper sections of cores SS-3A, SS-4A and SS-8A, and also in the lower sections of cores SS-4A and SS-2A. Inspection also revealed a heavy sheen associated with creosote-coated wood debris on the surface of cores SS-3A, SS-7A and SS-2A. The wood debris extended from the surface of these cores to a depth of 0.5 to 1 foot. In the remaining sections observers noted little to no sheen.

Figure 6: Note the sheen present in the sediment core.

The USCG submitted nine samples for PAH analysis (the top and bottom sections of cores SS-1A, SS-4A, SS-7B and SS-8A, and the truncated core SS7-A). PAHs were detected in all samples. One or more PAHs at concentrations exceeding DMMP SLs and/or Maximum Levels (MLs) were detected in the upper sections of SS-4A and in both sections of SS-8A.

Because a heavy sheen was observed in the lower section of core SS-2A, samples from both the upper and lower sections were subsequently submitted for PAH analysis. Both sections failed suitability criteria based upon SL and ML exceedences of one or more PAHs.

Results from the visual inspection and PAH analysis led the USCG to propose a significant reduction in the amount of material initially planned for open water disposal. Based upon this decision and DMMP agency approval, the project plan was modified to allow dredging of the redefined unsuitable sediments and previously identified "high spots" left behind after the last round of dredging. Dredging the unsuitable material proceeded without significant mishap and these materials were all disposed at an approved upland disposal facility. Removal of all contaminated material was verified with another bathymetric survey before dredging of suitable material could begin. After a final post-dredge survey to verify removal of all sediments to project design grade, the dredging contractor began dredging the remaining suitable materials.

As dredging of the suitable material began, however, USCG observers noted the dredge bucket pulling both large sections and small, splintered shards of remnant pilings from the remaining "suitable" material [Figure 7]. A heavy sheen accompanied this mixture of creosote-treated woody debris and sediment in the disposal barge, prompting the USCG to submit the situation to the DMMP agencies for another reevaluation. Ultimately, the USCG and DMMP agencies agreed that none of this material could be disposed in the DMMP Elliott Bay unconfined open water dredged material disposal site.

Figure 7: Photos documenting creosote-treated piling remnants and sheen accumulating in the disposal barge.

LESSONS

While roughly 17 years of history demonstrate that the PSDDA screening process accurately characterizes sediments to be dredged, this project raises questions about how effectively this process identifies contaminated material within the footprint of the pilings of a creosote-treated pier. It is clear that the PSDDA screening process did not accurately predict the presence of remnant creosote-treated pilings, which makes intuitive sense when sampling cores are collected in the sediments between pilings. Whether better piling removal would have changed the results is uncertain.

Dredging residuals, the material left behind on site after dredging, can be a source of surface re-contamination at dredging sites. Most literature addressing this topic discuss residual sources like side-slope failure, transport via the nepheloid layer, short-comings in or failure to follow dredging BMPs, and dredging equipment limitations. The USCG's project, however, demonstrates that failure to confirm (via post-dredge survey) dredging to design depth can also contribute to re-suspension and transport of contaminated sediments. In this case, surface sediment samples appear to confirm the theory that gravel column construction spread contaminated sediments that the dredging contractor left behind after reporting unsuitable dredging complete.

Working collaboratively, the USCG and DMMP agencies established a tiered testing framework intended to minimize testing costs, while concurrently protecting the aquatic ecosystem. The first tier of testing involved collecting surface sediment grabs, which needed to pass suitability criteria PAHs. Applying Best Professional Judgment (BPJ) based upon the creosote-sheen and previous testing results, the DMMP agencies did not require analysis for any other chemicals, which would increase costs without adding significant value to their subsequent suitability decision. Failure of the surface grabs to pass suitability criteria triggered collection and analysis of core samples. To save further analysis costs, the USCG decided against analyzing sections of the cores displaying sheen. While testing may have shown that the samples passed suitability criteria, site history and BPJ established a low probability that this would prove true.

This project emphasized the importance of monitoring the dredging process closely. Without the USCG's close oversight of dredging operations, sheen mobilized during the construction of the gravel columns may have spread well beyond the project site. Their oversight also led to a review of post-dredging survey data, which revealed the presence of contaminated material left on top of material originally destined for open-water disposal. Finally, without USCG oversight a significant amount of creosote-treated woody debris may have been disposed in open-water. This project demonstrates several ways that a dredging project can encounter unanticipated problems including: the presence of unanticipated contamination revealed in this case by creosote-sheen, and poor dredging control discovered after a review of post-dredging survey data.

The final lesson emphasized through this case study is the importance of collaborative relationships. Through its open and candid interaction with the DMMP agencies the USCG received timely agency decision-making and earned the agencies' trust, both of which resulted in significant savings and prevented the disposal of contaminated sediment in Elliott Bay.