SPECIFYING AND VERIFYING CONSTRUCTION PERFORMANCE FOR REMEDIAL CAPPING–A CASE STUDY FROM SAN DIEGO BAY, CALIFORNIA

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ABSTRACT

A sediment remediation project is currently being completed by the Unified Port District of San Diego at the former Campbell Shipyard site on San Diego Bay. Following site demolition and localized dredging, the project involves the construction of a sediment isolation cap comprised of multiple layers: a filter fabric base, a 0.6-meter (2-foot) layer of sand for chemical isolation, a layer of filter gravel and a protective surface layer of armor rock.

This project serves as a case-study example of the key considerations that are involved with designing and preparing bid specifications for construction of a complex sediment remediation cap under challenging conditions. This paper also discusses various methods used by the Port and its design engineer to oversee and verify the Contractor's work, so as to ensure that the remedial cap meets project specifications.

Project specifications were generally written to identify minimum performance criteria rather than specifying contractor means and methods. It was the Contractor's responsibility to determine the equipment and methods they would use to effectively achieve the required performance criteria. The specifications also required the initial construction of an initial "Pilot Cap" area, to demonstrate the Contractor's abilities to construct the cap to meet the performance criteria using the Contractor's proposed methods. During the Pilot Cap construction, the Contractor's initial technique of placing sand material resulted in significant amounts of overly-thick cap. Since then the Contractor has continued to refine their placement methods to provide tighter control of cap thicknesses.

Several monitoring methods were employed to measure and verify the accuracy of the capping operations. The Contractor provided daily progress bathymetric surveys that depicted the overall thickness of the materials placed and their surface elevations. The Port evaluated these surveys in conjunction with dive inspections and sediment probing of the placed cap thicknesses. Dive inspections were also used to evaluate whether previously-placed layers were being excessively disturbed by the ongoing work.

Keywords: Contaminated sediment, capping, material placement, bathymetric surveying, diver inspection, armor rock.

INTRODUCTION

The California Regional Water Quality Control Board (RWQCB) issued a Cleanup and Abatement Order (CAO) to the Port of San Diego (the Port) to remediate contaminated sediments over approximately 37,200 square meters (9.2 acres) of offshore area at the former Campbell Shipyard site, due to the presence of metals (copper, lead and zinc), petroleum hydrocarbons, PAHs, PCBs and TBT. The selected remedial alternative was to cap the sediments in-place in such a way as to prevent migration of the contaminants into the marine environment.

Construction of this project involved a complex sequence of demolition, debris removal, sediment dredging and installation of a multiple-layer isolation cap. Details of the design process were presented at the Western Dredging Association (WEDA) 2006 conference in San Diego, in a paper titled "Design of the Campbell Shipyard Sediment Remediation Project, San Diego, California."

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Demolition and dredging were completed in 2006. Capping activities are currently in progress. The Contractor for the work is Traylor Pacific, a division of Traylor Brothers, Inc.

SITE DESCRIPTION

The former Campbell Shipyard site is located on the northeastern shore of San Diego Bay between the San Diego Convention Center and the Tenth Avenue Marine Terminal (TAMT), at Eighth Avenue and Harbor Drive (Figure 1). This facility is owned by the Port and was first used for industrial operations in 1926 with the Campbell Industries Marine Construction and Design Company. Site operations focused initially on the construction of commercial fishing vessels, and later (in the 1980s) on naval ship repair.

Site operations stopped in the 1990s, and most of the shipyard facilities were demolished in 2000, except for a set of abandoned shipway ramps and marine railways extending bayward from shore near the middle of the site. The features that remained at the start of design – a shoreline seawall and a set of abandoned shipways – dated back to the earlier part of the 20th century. Figure 2 shows the layout of features to be constructed.

Figure 1. Site location in San Diego Bay.

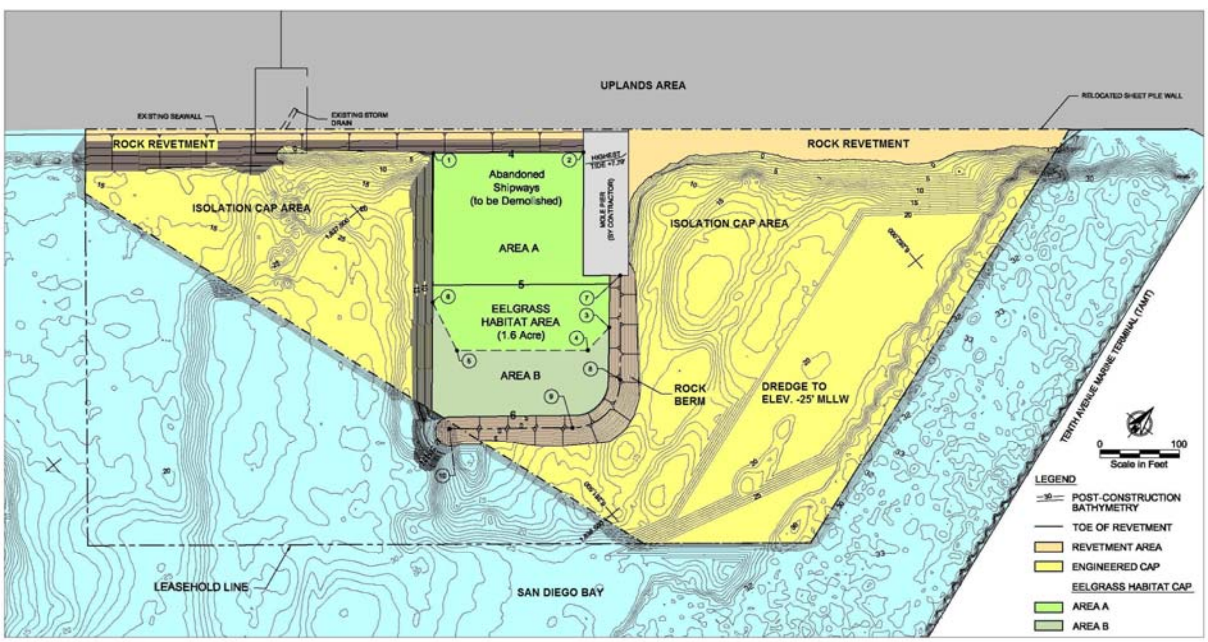

Figure 2. Map of Campbell Shipyard project site, extent of sediment cleanup and key project features.

CAP DESIGN

The sediment cap at the Campbell Shipyard site was designed to be consistent with current regulatory guidance for sediment capping: U.S. Environmental Protection Agency's (EPA's) "Guidance for In-Situ Capping of

Contaminated Sediments" (EPA 1998), published as part of the agency's Assessment and Remediation of Contaminated Sediments (ARCS) program; and Technical Report DOER-1 by the U.S. Army Corps of Engineers (USACE) Waterways Experiment Station, entitled "Guidance for Subaqueous Dredged Material Capping" (USACE 1998).

The sediment cap design had a required thickness of 1.5 meters (5 feet), and consisted of:

1. Geotextile layer – to provide separation from the contaminated sediments and base cap sand
2. Base cap layer – 0.6 meters (2 feet) of sand for chemical isolation
3. Gravel filter layer – 0.3-meter (1-foot) thick, to help support armor rock and prevent sand loss through the armor layer
4. Armor layer – 0.6 meters (2 feet) of surficial armor rock to protect the underlying layers from erosive forces

Figure 3 summarizes the final selected cap design for the site.

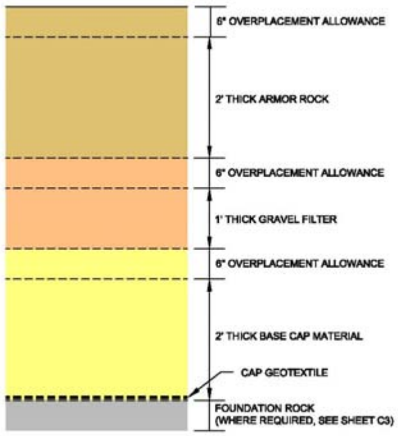

Figure 3. Summary cap design for sediment isolation cap.

Specifications for cap construction included paid overplacement allowances for each layer, as long as specified final post-capping grades were not exceeded in specified areas of the site.

Installation of Geotextile Layer

Prior to placement of capping materials, a layer of woven geotextile was laid down over the sediment surface. The purpose of this geotextile layer was to provide a stable base upon which the cap would be built, to prevent intermixing of cap sand with contaminated sediment, and to minimize the occurrence of mud waves in the underlying soft subgrade.

The geotextile was mounted in 14-meter (45-foot) wide rolls on a floating platform, and as it was unrolled, a series of rebar lengths (encased in PVC) were attached to the fabric at about 8-meter (25-foot) intervals. These rebar lengths acted as ballast to keep the geotextile weighted down as it was lowered into the water. The geotextile was laid down off the edge of the floating platform as the platform moved slowly forward. Figure 4 shows the geotextile placement operation.

Figure 4. Geotextile is unrolled and lowered into the water.

Source of Sand Material

Material for the sand cap was excavated from nearby Grand Caribe Island, an undeveloped, Port-owned parcel within the Coronado Cays residential area south of Coronado. This was an example of incorporating beneficial reuse into the project, as the Grand Caribe excavation represented the first stage of a separate Port project to create an intertidal marshland at that site. Figure 5 shows the excavation of sand from the Grand Caribe Island site.

Figure 5. Excavation of sand from Grand Caribe Island borrow site.

After surficial topsoil and brush was stripped off of the site, sand was excavated, stockpiled and fed to a conveyor which loaded it onto barges (Figure 6). The sand supply barges were transported across San Diego Bay to the construction site, where the sand was used for capping.

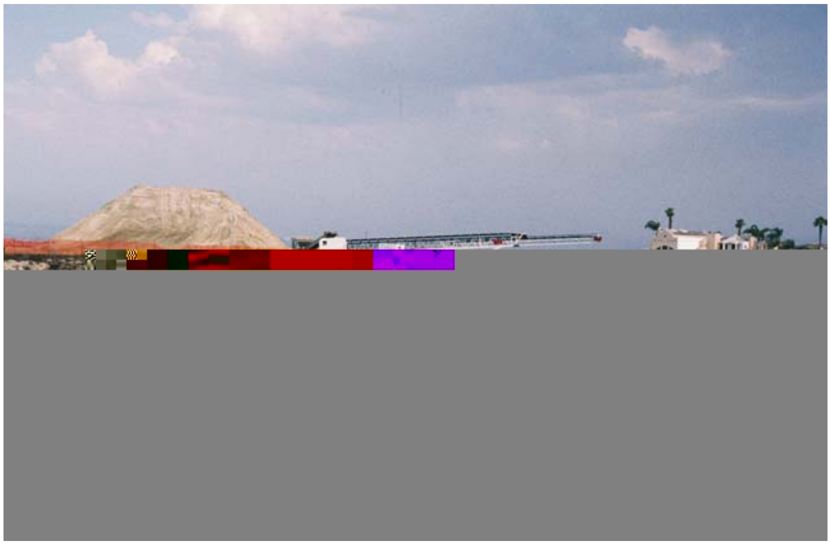

Figure 6. Conveyor set-up at Grand Caribe Island.

Performance Specifications for Cap Construction

The specifications for capping work were typically performance-based, such that it was the Contractor's responsibility to determine appropriate means and methods for cap construction to meet specifications – provided that the individual cap layers were successfully installed to the required thicknesses, without any disturbance or damage, and without exceeding final grade allowances in specified areas of the site. The specifications required the Contractor to remove material at their own expense if it exceeded the required finish grade elevations. A few specific methods were specified – such as the need to place the sand layer in individual lifts, restricted drop height for armor rock, and a gently sloping edge detail.

Prior to capping work, the Contractor was required to submit a Capping Plan, in which their proposed means and methods were presented. The Capping Plan was reviewed by the Port and its design consultants. After some initial comments on the first submitted Plan, a revised version was resubmitted. This resubmitted Capping Plan was accepted, but contingent on an in-the-field demonstration of capping performance through the required construction of a "Pilot Cap" section over a limited area of the site. Construction of this "Pilot Cap" was required in the specification as a way for the Contractor to demonstrate that their means and methods would result in an acceptable product. Performance of capping operations in the "Pilot Cap" is discussed later in this paper.

CAP CONSTRUCTION, QUALITY CONTROL, AND INSPECTION

Cap construction was done using a 118 metric ton (130-ton) capacity crane positioned on a 18-meter (60-foot) wide by 40-meter (130-foot) long barge. The crane barge was positioned using four anchor cables. Project specifications prohibited the use of temporary anchors or spuds within the capping area, because they would penetrate through the cap and their removal could resuspend potentially contaminated sediment. Therefore the contractor used a combination of landside anchoring piles (a series of steel H-piles driven to about 8 meters (25 feet) of embedment, located ten feet behind the site seawall), and marine anchors positioned outside and bayward of the sediment capping area.

The Contractor's crane was equipped with a real-time Differential Global Positioning System (DGPS) unit that fed directly to a real-time display on a monitor in the operator's cab, showing the position of the top of the crane (and thereby the suspended capping bucket) at all times. The real-time display could be overlain by a project base map on the cab monitor, so that the position of capping activity could be tracked in real time, and documented throughout the course of a work shift.

The Contractor was required to perform daily progress bathymetric surveys to determine the cap layer thicknesses. They used multi-beam surveying equipment to perform the daily progress surveys. Using the multi-beam data, the Contractor was able to produce survey contour maps showing bathymetric elevations and net thickness of capping layers (the difference between that day's elevations and the starting elevations). Figures 7 and 8 show examples of typical survey output.

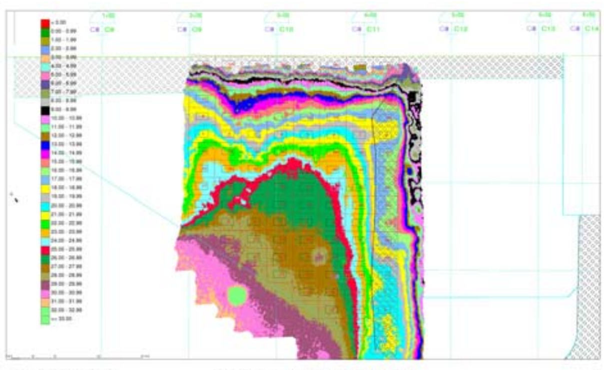

Figure 7. Progress survey, showing bathymetry.

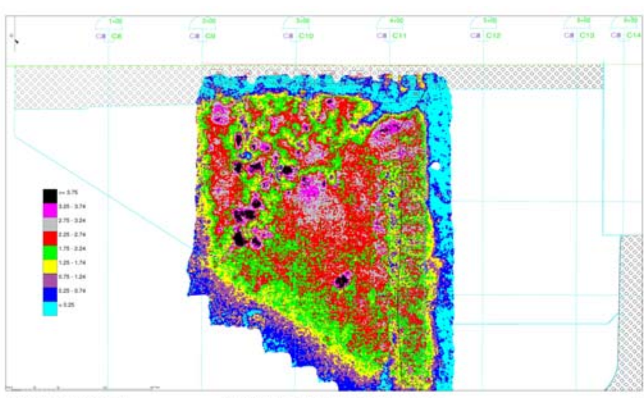

Figure 8. Progress survey, showing cap layer thickness.

The Port supplemented the Contractor's progress surveys using occasional diver observations of the recently placed materials. The divers "ground-truthed" the cap layer thicknesses indicated by the surveys, looking for possible damage or disturbance to cap materials; inclusions of debris; or indications of instability, movement, or mud waves. In addition, the divers probed the sand cap at regular intervals to measure its thickness, for comparison against the surveys.

In general, these diver observations found conditions and cap thicknesses (based on probing) that were consistent with the surveys. In some locations where the pre-existing subgrade was rocky, it appeared that the surveys underestimated the cap thickness or did not reflect sand that was present in and amongst the rocks. In these cases, the divers obtained probe measurements of sand coverage.

PERFORMANCE OF CAP CONSTRUCTION

Partial Construction of "Pilot Cap"

The Contractor started the capping operations by constructing a section of cap referred to as the "Pilot Cap." This portion of cap was located in the southern corner of the site, near TAMT – an area with restrictions on the final cap elevation, and thus requiring a greater degree of care to limit cap layer overplacement.

The Contractor's initial method was to place the sand base cap layer using a 9-cubic-meter (12-cubic-yard) skip box. The intention was to load the skip box with a known tonnage of material, position it over a known location, and slowly "sweep" the box while releasing materials into the water to cover a defined area. Figure 9 shows sand being placed using a skip box.

Figure 9. Placement of sand using skip box.

As sand placement proceeded, daily surveys indicated that the layer thickness was highly irregular. Sand thicknesses were observed to range from 0.3 meters (1 foot) to more than 1.8 meters (6 feet) in some cases. Some of this variability was attributed to control of the Contractor's initial baseline survey, as a few feet of initial survey offset led to anomalous thickness indications on sloping areas. The Contractor reworked the sand layer by using a clamshell bucket to remove areas with excessive overplacement, although this removal method was only partially successful as it oftentimes had a tendency to excavate too far into the sand layer.

After the sand layer was reworked to reduce the overly thick areas, some of the subsequent gravel layer was placed in the Pilot Cap area. Again some of the same placement difficulties experienced with the sand placement were experienced with the gravel layer placement including variable layer thickness and excessive overplacement. Furthermore, the elevation of the cap surface in the Pilot Cap area was approaching the final elevation limit for that area before the armor layer could even be placed. Due to difficulties in placing the cap layers accurately, operations in the Pilot Cap area were stopped, and the Contractor moved their operations to another portion of the site to further refine their placement techniques.

Capping of North Area

Capping operations were restarted in a different area of the site, immediately north of the eelgrass habitat area (shown on Figure 2). Here, there were no restrictions on final grades, which appeared to make it easier for the Contractor's placement operations. In this area, the Contractor shifted to sand placement with a clamshell bucket rather than the skip box and also improved the control on their baseline progress survey. In this area, the Contractor built up the sand layer in a more gradual fashion in an effort to better control overplacement. Figure 10 shows the use of a clamshell bucket for sand placement.

Figure 10. Placement of base cap sand using clamshell.

The base cap sand was placed with less variability of the final surface than it was in the Pilot Cap area. It was observed to undergo a "self-leveling" effect in which it tended to achieve a relatively flat surface, even over irregular topography. A seemingly related effect was its apparent tendency to preferentially build up in low areas as opposed to higher areas.

As the subsequent gravel layer was placed, surveys and diver observations indicated that the gravel did not show the same behavior as the sand layer did. It had a greater tendency to form mounds and to conform to the pre-existing (sand surface) topography. Divers excavated small test holes in the gravel to confirm that it was not mixing into the underlying sand layer.

Finally, a 0.6-meter to 0.9-meter (2-foot to 3-foot) thick layer of armor rock was placed. A skip box was used to place the armor rock, from just above the water's surface. Because of the Port's stated concern that the armor rock not damage the underlying gravel upon its impact on the gravel surface, a small amount of armor rock was initially placed in a defined area, and immediately observed by divers. These observations indicated that the armor rock was not "punching in" to the gravel but rather was forming a discrete and separate layer immediately atop the gravel.

ENVIRONMENTAL PROTECTION

Project permits and specifications required all dredging and capping activities to be surrounded at all times by a double set of silt curtains. The size, type and arrangement of the silt curtains was left to the Contractor's discretion, subject to the Engineer's approval, and provided that water quality criteria were met at all times. The Contractor deployed their double silt curtains in a large semicircular area that encompassed much of the site, so as to minimize repositioning the curtains as equipment moved around within the site.

Port staff conducted water quality monitoring on a daily basis during in-water construction activity. Monitoring was conducted just outside the silt curtain enclosure and included observation and measurement of turbidity levels at the water surface and at mid-depth below the surface. The criterion for water quality was that turbidity measurements could not be more than 20 percent higher than 'background' turbidity measurements.

The Contractor's operations and silt curtain usage have been successful at meeting water quality requirements, through the time of this writing.

CONCLUSIONS

Capping at the Campbell Shipyard site is a complex and challenging activity. The specifications were performance-based, rather than method-based, thus requiring the Contractor determine their own means and methods, to provide opportunities for cost efficiencies. Placement equipment and methods appear to have a significant effect on the accuracy of cap placement. Several controls and monitoring methods were used to assess the Contractor's operations; most notably in the requirement for a "Pilot Cap" to be constructed, and in providing for diver observations of the surveyed cap layers. These controls and monitoring methods are important to ensure that the cap is constructed to meet design specifications.

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