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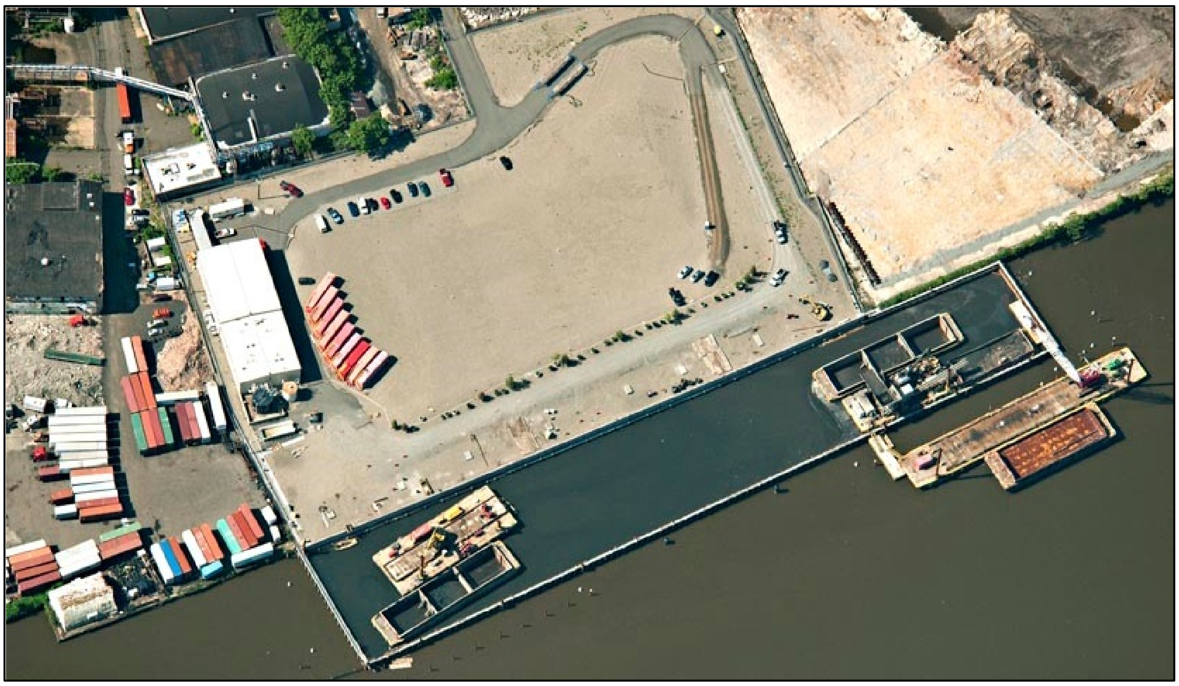

Lower Passaic River NTRCA in Progress
(Photo Courtesy of Tierra Solutions/ARCADIS/The Intelligence Group)

IN THIS ISSUE

AIMS & SCOPE OF THE JOURNAL

The *Journal of Dredging* is published by the Western Dredging Association (WEDA) to provide dissemination of technical and project information on dredging engineering topics. The peer-reviewed papers in this practice-oriented journal will present engineering solutions to dredging and placement problems, which are not normally available from traditional journals. Topics of interest include, but are not limited to, dredging techniques, hydrographic surveys, dredge automation, dredge safety, instrumentation, design aspects of dredging projects, dredged material placement, environmental and beneficial uses, contaminated sediments, litigation, economic aspects and case studies.

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DESIGN OF PHASE I OF THE USEPA NON-TIME CRITICAL REMOVAL ACTION IN THE LOWER PASSAIC RIVER

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ABSTRACT

The Phase I Removal Action in the Lower Passaic River consisted of dredging approximately 30,600 cubic meters (CM) of highly contaminated sediment to a depth of 3.7 meters within a sheet pile cofferdam (enclosure). The dredged material was subsequently processed and dewatered, all of which required innovative approaches to design. The objective of the work was to remove sediments containing the highest dioxin concentrations in the Lower Passaic River Study Area (LPRSA). The sediments also contained elevated levels of polychlorinated biphenyls (PCBs), herbicides, pesticides, volatile organic compounds (VOCs), and semivolatile organic compounds (SVOCs). Sediments were classified based on in-situ characterization as Environmental Media (EM; waste that does not demonstrate hazardous characteristics and can be directly disposed of at a Subtitle C landfill) or Hazardous Characteristic Material (HAZ; waste that requires treatment [e.g. incineration] prior to disposal). The design included multiple processes: mechanical dredging, screening and slurrying of dredged material, and pipeline transport of the slurry to an upland processing facility; dewatering of the slurry using membrane filter presses; water treatment; off-site transport, treatment, and disposal; backfill; and air emissions and odor control.

This paper describes the project design including challenges faced, innovations implemented, and successes realized. The partner article within this issue describes the subsequent construction of the project.

Keywords: CERCLA, contaminated sediment, dioxins, dredging, Superfund, design-build

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INTRODUCTION

An Administrative Settlement Agreement and Order on Consent (AOC; USEPA 2008) was entered into by the U.S. Environmental Protection Agency (USEPA), Occidental Chemical Corporation, and Tierra Solutions, Inc. (Tierra) in June 2008, requiring the Phase I Removal Action, which consisted of removal and disposal of 30,600 cubic meters (CM) of Passaic River material located adjacent to Operable Unit 1 (OU-1) of the Diamond Alkali Superfund Site. The site is located at 80 and 120 Lister Avenue, Newark, New Jersey, approximately 5.5 kilometers (km) upstream of Newark Bay.

The main objective of the work was to remove the highest concentrations of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) found in the LPRSA. To achieve this objective, dredging was conducted to 3.7 meters (m) below sediment surface (bss) within the footprint of the Phase I Work Area. The Removal Action activities were conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan as a Non-Time Critical Removal Action. A Phase I Engineering Evaluation/Cost Analysis (Phase I EE/CA; Tierra 2008) was prepared to develop and evaluate project alternatives. The Phase I Removal Design Work Plan (Phase I RDWP; Tierra 2009) was prepared and describes the process employed to design the project alternative and meet the Removal Action Objectives (RAOs) established by USEPA for the Phase I Removal Action:

- RAO #1: Remove a portion of the most concentrated inventory of 2,3,7,8-TCDD and other hazardous substances to minimize the possibility of migration of contaminants due to extreme weather events.
- RAO #2: Prevent, to the maximum extent practicable, the migration of resuspended sediment during removal operations through appropriate engineering controls, monitoring, and other methods.
- RAO #3: Prevent, to the maximum extent practicable, the potential for spillage or leakage of sediment and contaminants during transport to the disposal facility.

The RAOs were established to determine the relative success of the Phase I Work; therefore, the design was developed with these in mind. Additionally, protection of community health and safety was implicit in these RAOs.

SITE DESCRIPTION

The Phase I Work Area included the enclosure area, where excavation and subsequent backfilling were conducted. The Phase I Work Area was located within the Harrison Reach of the LPRSA, which is approximately 27 km long and extends from the Dundee Dam near Garfield, New Jersey, to Newark Bay. Figures 1 and 2 illustrate the extent of the LPRSA and the Phase I Work Area.

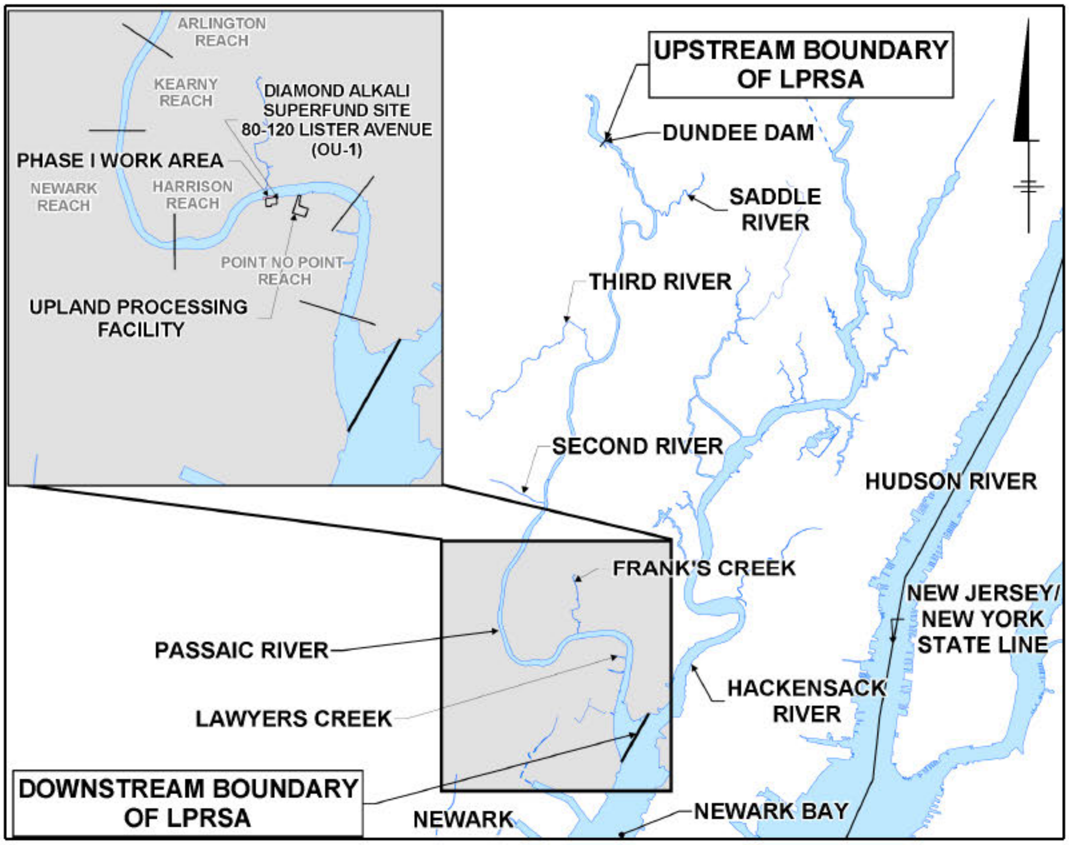

Figure 1. LPRSA and the Phase I Work Area

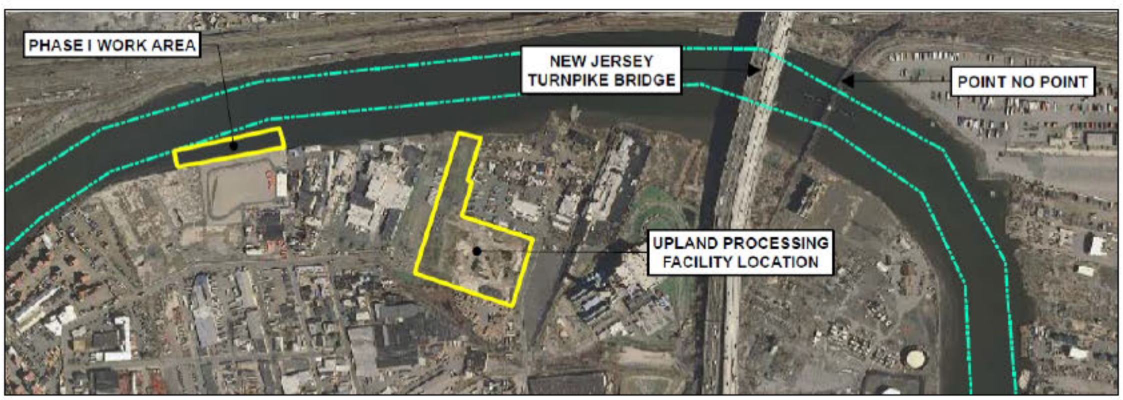

Figure 2. Phase I Work Area and Upland Processing Facility location

The Phase I Work Area was approximately 0.8 hectare in size, measuring 229 m long by 34 m to 41 m wide, and was located completely outside of the adjacent federal navigation channel. The Passaic River is tidal, with about a 1.8 m tidal fluctuation at the project site. The Phase I Work Area was regularly exposed during low tide conditions, as shown in Figure 3.

Figure 3. Looking east at the Diamond Alkali OU-1 Facility and the Phase I Work Area

According to a 2009 bathymetric survey, the sediment bed elevation varied from –1.8 m National Geodetic Vertical Datum of 1929 (NGVD29) at the deepest point of the Phase I Work Area to generally +0.3 m NGVD29 along existing shoreline structures. The Phase I Work Area consisted of shallow subtidal and intertidal mudflats with little or no associated vegetation, and the shoreline was formed by existing structures (bulkheads, riprap, buildings, parking lots, roads, and other structures). The riverbed generally sloped from the shoreline toward the navigation channel at an approximate 4 percent slope. Generally, the Phase I Work Area sediment consisted of a 3 to 6 m layer of fine-grained, cohesive material classified as moderate to high-plasticity organic silt and clay underlain by medium dense silty sand.

OVERVIEW OF REMOVAL DESIGN PROCESS

The USEPA Phase I Action Memorandum (USEPA 2009a) described the USEPA-selected alternative: mechanical removal of material within a sheet pile enclosure and sediment handling and processing (i.e., mechanical dewatering), with processed material transported to an off-site treatment and/or disposal facility. Following the issuance of the Action Memorandum, Tierra began developing plans for design, including collecting necessary pre-design data. Throughout the design process, Tierra worked cooperatively with USEPA and stakeholders to seek input and to communicate design developments. This required early and frequent communication with the community, including the Community Advisory Group (CAG), to engage them in the design process.

The Phase I Removal Action was completed as a design-build project to meet the 2008 AOC scheduling requirements and subsequent USEPA modifications (USEPA 2008 and 2009b, respectively). The design-build project relied on specification of performance criteria rather than the means and methods of a design-bid-build project. Additionally, the primary subcontractors were involved with, and provided input on, their components of the final design.

The overall design process consisted of three main stages:

- Pre-Design Studies: This stage consisted of collecting and analyzing data necessary to support the design. It also included evaluation and selection of the upland processing site. The following studies were conducted:
  - Sediment Assessment
  - Geotechnical Assessment
  - Waterfront Structure Survey
  - Bathymetry and Debris Survey
  - Groundwater Assessment
  - Hydrodynamic Assessment
  - Treatability Studies (Sediment processing, Water Treatment, Air Emissions)
  - Upland Process Facility (UPF) Assessment
- Pre-Final Design
  - This stage consisted of design analysis for each project element which incorporated the pre-design data and contractor input. The pre-final design package included a design report, technical memoranda for each design element, and a complete set of drawings and specifications. The pre-final design was submitted to USEPA for review.
- Final Design
  - The final design incorporated comments from USEPA (and other agencies including the U.S. Army Corps of Engineers [USACE] and New Jersey Department of Environmental Protection [NJDEP]) and resulted in a complete design package, approved by USEPA, and ready for implementation.
  - Supplemental supporting documents (e.g., final pre-design reports, the results of hydraulic modeling, Construction Quality Assurance Plan [CQAP], Removal Action Work Plan [RAWP]) were developed and submitted separately.
  - A Substantive Requirements Compliance Action Plan (SRCAP; Tierra 2011) was prepared to describe how Applicable or Relevant and Appropriate Requirements (ARARs) and their associated substantive requirements would be met by the design.

DESIGN OF PHASE I REMOVAL ACTION

The Phase I Removal Action design elements: sediment excavation enclosure; sediment removal; hydraulic pipeline; UPF; sediment handling and processing; water treatment; off-site transport, treatment, and disposal; and control of air emissions and odors; are described below. The Sediment Removal Operations Process Flow Diagram is presented below in Figure 4.

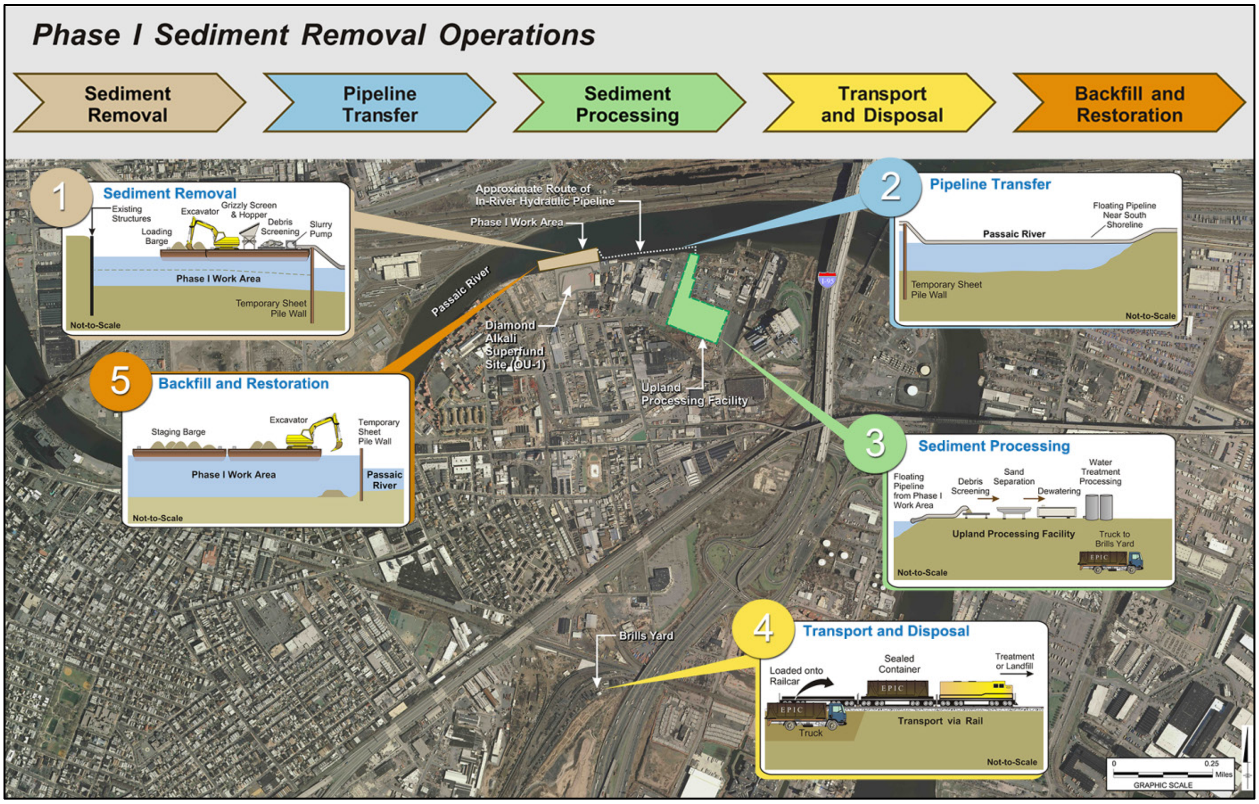

Figure 4. Sediment Removal Operations Process Flow Diagram

Sediment Removal Enclosure

The USEPA-selected alternative required a steel sheet pile enclosure to contain sediment resuspension during removal and backfill activities in accordance with RAO#2 and to support an excavation depth of 3.7 m bss. The sheet pile enclosure was also needed to provide sufficient draft for the barges and equipment working within it and allow for maintenance of water levels during tidal fluctuation of the river.

The enclosure design consisted of three sheet pile walls on the west (upstream), north (riverside), and east (downstream) sides of the Phase I Work Area (Figure 5). The enclosure design included king piles embedded to approximately 16 m bss for primary lateral support and interlocking Z-shaped piles to create the continuous enclosure. The piles were sealed to mitigate water leakage and loss of sediment through the interlocks. The fourth side of the enclosure was a combination of the existing OU-1 Floodwall and sheet piles installed in front of the existing wall of the Sherwin-Williams (S-W) property. The enclosure was designed as a temporary wall to be extracted following backfilling. Due to the depth of the removal, the OU-1 Floodwall required additional structural support to mitigate the loss of passive forces provided by the sediment. This was accomplished with the installation of grouted tieback anchors (into the OU-1 landside), which were designed to remain in place following the Phase I Removal Action.

The enclosure design also included:

- Ancillary structures to protect the enclosure from external loads or to support other specific functions (e.g., barrier monopiles, dolphins, a weir gate, and pump)
- A single H-pile support incorporating a fender unit to aid in "conforming" the irregular profile of the adjacent property timber bulkhead
- Scour protection measures in areas susceptible to erosion due to the presence of the enclosure, as determined using a three-dimensional hydrodynamic model (Delft3D).
- Supplementary features, such as aids to navigation and Notices to Mariners
- A temporary gravel access road at the OU-1 upland site

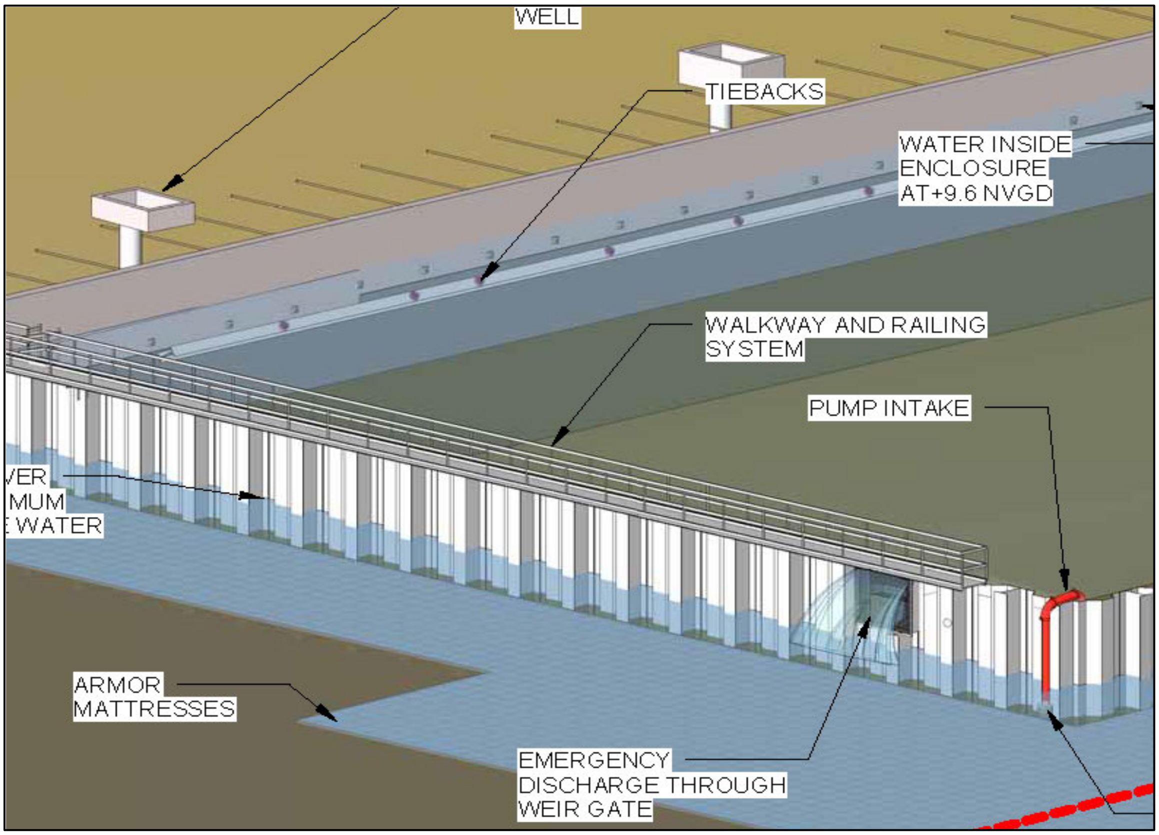

Figure 5. Sediment Excavation Enclosure

The enclosure basis of design was developed to account for a variety of loading cases or load combinations. The enclosure itself was designed to withstand the rising river water elevations for a 100-year storm and an excavation depth of 3.7 m, plus over-excavation of approximately 0.1 m. Differential hydrostatic head for water levels inside versus outside the enclosure was accounted for, both for normal tidal conditions and for the 100-year storm, through contingency measures. Contingency measures are aspects of the design triggered by events that exceed the pre-determined design loading conditions. They were intended to mitigate adverse impacts to the enclosure, thereby reducing the risk of dispersion or migration of the Phase I Removal Action sediments. Contingency measures were developed for extreme river stages, vessel impact, and ice or debris accumulation or impact.

Sediment Removal

The material inside the enclosure was designated to be dredged to a depth of 3.7 m bss based on the Administrative Order on Consent requirement, with a 9-centimeter (cm) overdredge allowance. The dredge area was made up of seven distinct dredge units, with two different waste classifications: EM and HAZ. The waste classifications of the dredge units were determined through pre-design investigation sampling as described in the off-site transportation, treatment, and disposal section below. The elevations of the dredge units between zero and 3.7 m below sediment surface (i.e., zero to 1.8 m, 1.8 to 2.4 m) were designated based on the waste characterization of the material. The design specified use of a real-time kinetic digital global positioning system (RTK-DGPS) on the dredge to allow tracking of dredging activities and assist with segregation of EM and HAZ material. Segregation of EM and HAZ material was critical to preserving the application of in-situ characterization of the material for disposal profiling purposes. Dredging operations were planned for 12 hours per day, 6 days per week (Monday to Saturday).

Hydraulic Pipeline

The design team evaluated the best approach for conveying the dredged material to the UPF. Passaic River navigation traffic, tidal fluctuations, and RAO #3 (preventing spillage or leakage of sediment during transport), were all factors in the evaluation. As a result, the design team concluded that screening and slurrying the dredged sediment at the Phase I Work Area, and pumping it through a hydraulic pipeline to the UPF, was the most feasible and technically sound approach. The hydraulic pipeline was designed to float along the south side of the Passaic River to the UPF, and anchors were used to control horizontal movement. A dual-containment high-density polyethylene pipeline (HDPE) pipe was selected, which offered natural buoyancy due to the space between the inner and outer pipes. The inner pipeline had a nominal inner diameter of 15.2 cm. The outer pipeline had a nominal outer diameter of 30.5 cm. The dual-containment pipeline provided protection from exterior impacts as well as secondary containment in the event of a leak from the inner pipeline.

Upland Processing Facility

While the OU-1 upland site is located immediately adjacent to the Phase I Work Area, it was generally unsuitable for most remedial support activities due to limited usable space. In addition, because a large portion of the OU-1 upland site consists of an environmental cap resulting from previous remediation activities, use of OU-1 was restricted to prevent damage to the cap. Therefore, an off-site UPF was required for sediment processing, decant water treatment, and loading of containers for off-site transportation. Determining the location of the UPF was one of the major project challenges. During the design process, a number of potential UPF sites were evaluated, and a UPF site was selected during the preliminary design in 2009. However, in 2011 during the final design, the UPF site was changed due to unforeseen circumstances.

The final selected UPF location was leased property located at 117 Blanchard Street in Newark, New Jersey. The UPF was a 4.3-hectare parcel located on the Passaic River. To complete the UPF design, a geotechnical and civil design analysis was conducted, including settlement and bearing-capacity analysis for structures with high ground pressures, or settlement-sensitive structures such as the tanks and equipment used for sediment processing and water treatment. A pavement section analysis was also completed for the sediment processing, water treatment, and loading areas. The final UPF site had different soil characteristics (e.g., lower bearing capacity) than the previously selected UPF site and required engineering controls for stabilization, resulting in significantly more robust equipment pads and foundations than originally designed.

Sediment Handling and Processing

Sediment handling and processing included equipment at the Phase I Work Area and at the UPF as shown on Figures 6 and 7. Working closely with the sediment processing and dredging subcontractors, the engineering team designed a sediment screening and slurrying process located on a barge within the enclosure. This process consisted of offloading the dredged material into a hopper fitted with a grizzly screen, followed by a trommel screen. These screens removed debris larger than 10 millimeters (mm) from the dredged material. A sprayer was used to wash the remaining material through the screens into a slurry makeup tank. A hydraulic feed pump was designed to pump the sediment slurry, containing approximately 10 to 15 percent solids by weight, into the hydraulic pipeline at a flow rate of approximately 3,300 liters per minute. The hydraulic pipeline was connected to the sediment processing plant at the UPF.

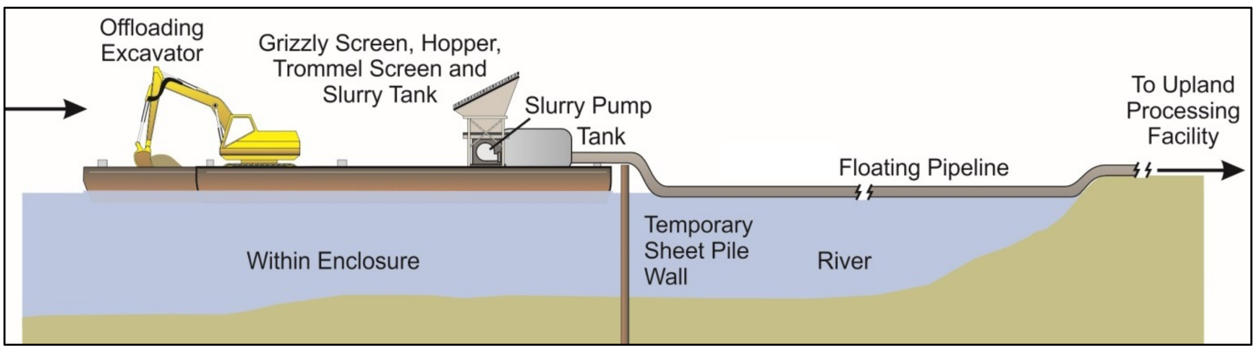

Figure 6. Sediment handling and processing at the Phase I Work Area and pipeline transfer

After passing through the hydraulic pipeline to the UPF, the sediment slurry would pass through a shaker screen, followed by hydrocyclones, to separate out the coarse fraction of the material (greater than 0.075 mm, less than 10 mm), which was then dewatered by a vibratory screen. Following separation of coarse solids (disposed of according to waste type), the fine-grained slurry was pumped to a gravity thickener to thicken the slurry and increase the percent solids to approximately 15 percent. Thickened sediment slurry was pumped from the gravity thickener to sludge storage tanks, which provided process equalization for feeding the mechanical presses and temporary storage of thickened slurry to allow for 24 hour/day operation of the presses. The thickened slurry was mechanically dewatered using Membrane Filter Presses (MFPs). Polymer was added to the slurry prior to the gravity thickener and again prior to the MFPs.

MFPs were selected due to their higher performance, similar lead times, and slightly lower overall estimated cost (when factoring in operations, transport, treatment, and disposal) compared with standard plate and frame presses. The design criteria for the target percent solids of the dewatered filter cake was 57.5 percent, based on treatability testing and the expected performance of the presses. MFPs are similar to standard plate and frame presses but have an impermeable membrane in addition to the filter cloth. Half of the plates in an MFP have a membrane on both sides of the plate behind the filter cloth, which allows membrane pressure to be placed on all of the recesses. In comparison with a belt filter press and standard plate and frame press, MFPs generally achieve the highest solids contents due to the membrane pressure applied. MFPs also typically have shorter cycle times than plate and frame presses. The MFPs (DIEMME Model GHT 1.500 P13 Overhead Beam) were built specially for the project and had a lead time of more than 6 months. Four 10 CM capacity MFPs were designed to provide capacity to dewater 382 in-situ CM per day. The MFPs were designed to be modular units that can be reused for subsequent projects by the sediment-processing contractor.

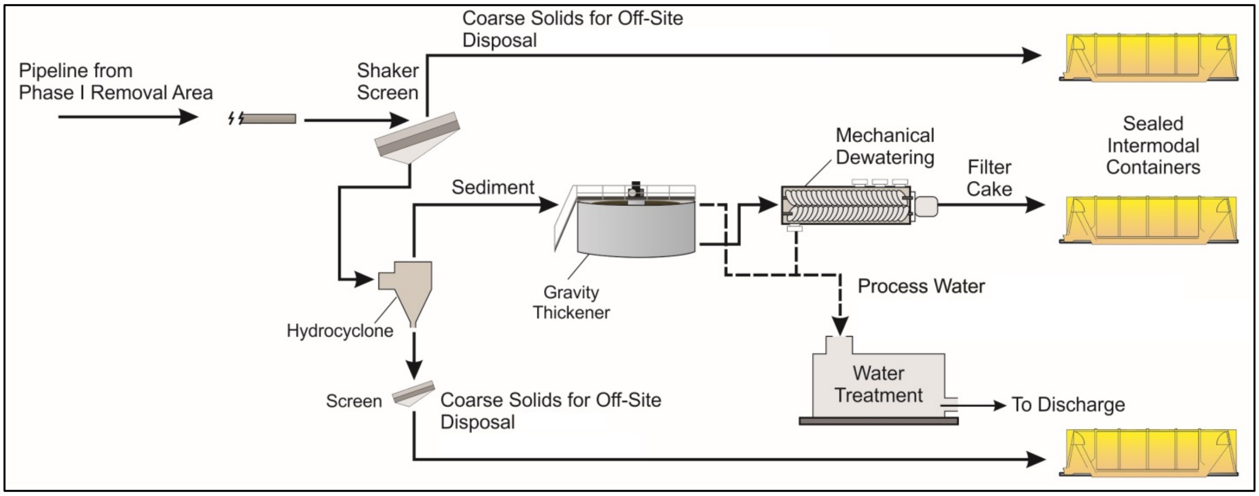

Figure 7. Sediment handling and processing at the UPF

Water Treatment and Discharge

The temporary water treatment system was designed to treat water generated during the sediment processing activities to meet permit equivalency effluent limits. Sediment process water was generated at the UPF by the gravity thickener overflow and the MFPs (filtrate water). The hydraulic capacity of the temporary water treatment system accommodated the flows from sediment processing, water treatment equipment backwash, hydraulic pipeline flush water, and stormwater from the UPF with the potential to contact sediment.

The temporary water treatment system consisted of coagulation, clarification with polymer-addition, multistage filtration using multimedia filters (MMFs), and liquid-phase granular activated carbon (GAC) adsorption. Particles (greater than 0.1 mm) were removed within the clarification process. Further particle and total suspended solids removal were achieved by the MMF and GAC. GAC was the primary treatment process for organics, including VOCs, SVOCs, dioxins/furans, pesticides, and herbicides. The water treatment system was designed for continuous-flow mode, with equalization tanks to balance the flow. Treated effluent was designed to be discharged to the river or reused. Reuse was limited to polymer make-down and washing down sediment processing filter presses or equipment, provided the water was collected and treated again in the water treatment system after reuse.

Off-Site Transport, Treatment, and Disposal

In Situ Characterization Approach

In-situ characterization data from the pre-design investigation were used to develop the disposal profiles for dredged material (filter cake, coarse solids, and debris). The sample frequency of one sample per approximately 425 CM of in-situ sediment met or exceeded the characterization requirements (40 CFR 261) of the treatment and disposal facilities considered in the design. The pre-design toxicity characteristic leaching procedure (TCLP) results were used to determine the applicable Resource Conservation and Recovery Act (RCRA) disposal requirements and to define the two material disposal profiles as follows.

Environmental Media (EM) – Sediment that did not exceed RCRA regulatory levels was EM and was eligible for direct land disposal without any additional treatment or testing. This category applied to 60 of the 72 pre-design investigation samples, which represented approximately 84 percent of in-situ material.

- Characteristic Hazardous Waste (HAZ) – Sediment classified as HAZ and which contained Underlying Hazardous Constituents (UHCs) exceeding ten times the Universal Treatment Standard (UTS) required treatment prior to disposal. This category applied to 12 of the 72 pre-design investigation samples, which represented approximately 16 percent of in-situ material. The hazardous characteristics resulted from RCRA exceedances for one or more of the following: 2,4-dichlorophenoxyacetic acid, Endrin, heptachlor, heptachlor epoxide, 2,4,6-trichorophenol, 2,4-dinitrotoluene, benzene, chlorobenzene, cadmium, and lead. These pre-design investigation results also indicated UHCs exceeding ten times the corresponding UTS were present; therefore, sediments represented by these samples required treatment prior to disposal. UHCs include cadmium, lead (although zinc exceeded the applicable UTS, it was not considered a UHC in characteristic hazardous waste per §268.2[i]), PCBs, dioxins, herbicides, pesticides, VOCs, and SVOCs.

Although a variety of treatment technologies exist for organic constituents (e.g., chemical oxidation, carbon adsorption, and combustion), and research and development efforts are underway for new treatment technologies for dioxins, the only proven treatment technology for the Phase I Removal Action sediments (that contain dioxin as a UHC) was incineration (Congress of the United States Office of Technology Assessment 1991) under the operating requirements established in 40 CFR Part 264 Subpart O and Part 265 Subpart O. Therefore, HAZ material required incineration, and the resulting incinerator ash required disposal at a RCRA Subtitle C disposal facility.

Designing removal and sediment handling and processing to preserve segregation of EM and HAZ material was critical to preserving the application of in-situ characterization for disposal profiling purposes. The design included handling dredged materials in accordance with the in-situ characterization results of the dredge unit from which they were generated and maintaining the segregation and tracking of materials throughout sediment handling and processing.

Offsite Transport, Treatment, and Disposal Facilities

Potential disposal and treatment facilities were extensively evaluated as part of the design, including facility visits and audits. A hazardous waste incinerator was selected for treatment of HAZ materials. A Subtitle C landfill facility was selected for disposal of EM materials and incinerated HAZ material. Transport methods (e.g., truck, barge, and rail) were also evaluated concurrently with treatment and disposal facilities. Rail was selected as the preferred transport method due to its cost-efficiency, sustainability, and safety. Because rail was not available at OU-1 or the UPF, the design included trucking of containers to a nearby transload facility, followed by rail transport to treatment and disposal facilities, as shown in Figure 8.

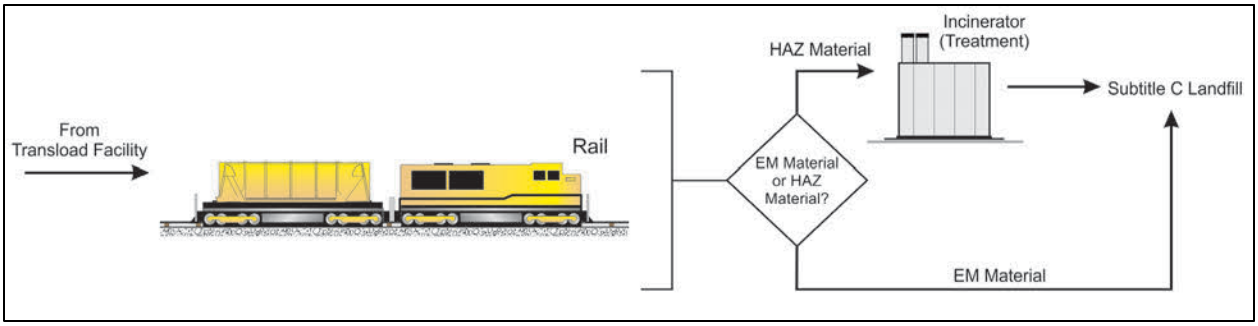

Figure 8. Off-site transport, treatment, and disposal process

Backfill

Following removal activities at the Phase I Work Area, the area within the sheet pile enclosure required backfilling. Part of the function of the backfill was to replace the passive pressures against the existing shoreline structures (the S-W Wall and the OU-1 Floodwall). To achieve this objective, the backfill was designed to be placed to at least the pre-construction elevation. The design specified backfill material with physical characteristics similar to the in-situ sediment, but with improved engineering and structural properties such as a lower plasticity index. In addition, because excessive scour of the backfill material could destabilize the existing structures, the design included placement of relatively coarse material (D50 of 2 to 4 mm) in the top 0.6 m (i.e., 0.6 to 0 m bss) at a minimum to help reduce surface scour of the backfill material.

Air Emissions and Odor Control

Air modeling was performed to evaluate the potential for sediment removal, sediment handling and processing, and water treatment to generate air emissions and odors. Two air emission conceptual models were developed: one for the Phase I Work Area and one for the UPF. The following four mechanisms were evaluated:

- Volatilization: The model used to estimate volatilization of chemicals from the exposed and ponded sediment was based on algorithms provided by the Dredging Operations and Environmental Research Program, a division of the USACE (2008). The volatilization of chemicals from liquid surfaces was modeled using USEPA Air Emissions Models for Water and Wastewater (USEPA 1994) algorithms. The output of the volatilization model was a

chemical flux rate (i.e., mass of chemical volatilized per square meter per second). Using the flux rate and the source surface area, a total emissions rate was calculated for the Phase I Work Area and the UPF. The overall volatilization model was calibrated using pre-design treatability studies (including the USACE laboratory volatile emissions test) to increase the accuracy of the model.
- Dispersion: For dispersion modeling, the NJDEP allows for a step-wise approach beginning with a screening assessment (NJDEP 2009). The screening-level assessment was performed using SCREEN3, a dispersion model developed by the USEPA using algorithms presented in Screening Procedures for Estimating the Air Quality Impact of Stationary Sources (USEPA 1995). The volatilization model output (i.e., flux rate) was used in the dispersion model to determine a downwind chemical concentration in air.
- Fugitive Dust: Fugitive dust from wind erosion was modeled using equations from the Air/Superfund National Technical Guidance Study Series (USEPA 1989). Fugitive dust from material handling was modeled using methodology provided in AP 42 Compilation of Air Pollutant Emission Factors (USEPA 1994). The predicted fugitive dust emissions were lower than regulatory thresholds.
- Vehicle and Engine Emissions: Anticipated internal combustion engines and associated emissions were evaluated using Federal Emission Standards (40 CFR Parts 9, 86, and 89). Estimated emissions were below State of the Art Technology (SOTA) threshold.

Potential hydrogen sulfide (H_2S) emissions were also evaluated. The estimated on-site H_2S concentration at the Phase I Work Area was lower than worker safety criteria, and the estimated off-site H_2S concentrations for the nearest industrial, commercial, and residential receptors were lower than the NJDEP reference concentration for short-term exposure. Potential odorous compounds include site constituents of concern (COCs; e.g., VOCs, SVOCs) and naturally occurring, sulfur-containing compounds in the sediment such as H_2S. Based on a comparison of model-predicted chemical concentrations to individual odor thresholds, odors were predicted from COCs and H_2S at the Phase I Work Area and COCs at the UPF.

Air and odor emission controls included best management practices (BMPs) and required controls. BMPs were not required, but due to their effectiveness and ease of implementation, were incorporated into the design. Required controls were implemented because of regulatory requirements (e.g., predicted emissions above SOTA thresholds) or predicted concentrations above worker safety standards. Selected air and odor controls included:

- Maintain enclosure water level to reduce exposure of tidal flats/sediment to air (BMP)
- Water spray on grizzly and trommel screen during operations (BMP)
- Rinse oversize and large debris as needed to remove adhered sediment (BMP)
- Transport sediment in a hydraulic pipeline from Phase I Work Area to UPF (BMP)
- Close lids of containers or cover with liner after filling (BMP)
- Cover the sludge storage tanks (required control)
- Employ personal and zone monitoring for VOCs and H_2S (required control)
- Tarp sediment barges during non-operational hours (BMP)

A perimeter air-monitoring program was developed to monitor PCBs, dioxins, dichlorodiphenyltrichloroethane (DDT), and chlorobenzene at the Phase I Work Area, the UPF, and two nearby residential areas.

CONCLUSIONS

In the 3 years following issuance of the AOC, the project team completed the EE/CA, pre-design studies, and a final USEPA-approved design. The technical challenges of the project were addressed by conducting extensive pre-design studies and performing a detailed design analysis for each project element including approaches to reduce potential impacts to quality of life (e.g., odor, noise, light, traffic, navigation). Frequent communication with USEPA was critical to successfully completing the design on schedule. In addition, Tierra and USEPA proactively engaged and communicated with the community, including the CAG, to transform potential community fears and resistance into a focus on meaningful roles and benefits for local people. The design-build approach allowed for a streamlined and expedited design process as well as an efficient and rapid transition from design to construction. Project construction is described in the companion paper included in this issue.

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CONSTRUCTION OF PHASE I OF THE USEPA NON-TIME CRITICAL REMOVAL ACTION IN THE LOWER PASSAIC RIVER

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ABSTRACT

The Phase I Non-Time Critical Removal Action project was conducted in 2011/2012 within the Lower Passaic River Study Area (LPRSA). The project consisted of removing approximately 30,600 cubic meters (CM) of sediments containing the highest dioxin concentrations in the LPRSA and conveying it to a downstream facility, where it was dewatered and prepared for off-site treatment/disposal. Safely dredging dioxin-containing sediment to a depth of 3.7 meters (m) in an active river and tidal environment requires innovation and extensive planning. A combination wall cofferdam (enclosure) was constructed to isolate the work area from the surrounding tidally influenced river, and to provide adequate draft for dredging equipment. The sediment was mechanically dredged, screened and slurried, and conveyed through a pipeline to an upland processing facility (UPF), where it was processed and dewatered using membrane filter presses (MFPs). Sediments were characterized in-situ as either Environmental Media (EM; waste that does not demonstrate hazardous characteristics and can be directly disposed of at a Subtitle C landfill) or Hazardous Characteristic Material (HAZ; waste that requires treatment [e.g., incineration] prior to disposal). Dewatered material was trucked from the UPF to a nearby transloading facility for shipment by rail to either a landfill (EM material) or an incineration facility (HAZ material). Following dredging, the Phase I Work Area was backfilled to grade.

Keywords: CERCLA, contaminated sediment, dioxins, dredging, Superfund, design-build

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INTRODUCTION

This paper gives an overview of the construction portion of the project and discusses project challenges as well as lessons learned. The partner article within this issue describes the design of the Phase I Removal Action and provides an overall introduction to the project including a summary of objectives, site background, and regulatory process.

Due to the unique properties of the project site and the nature of impacted sediment, accomplishment of the project goals required comprehensive, collaborative, and practical efforts among many entities and processes. This article will describe the execution of each project component from the beginning of site preparation to final disposal of processed sediments. The details of construction will demonstrate a customized response to client need and positive outcomes from a true team effort.

CONSTRUCTION APPROACH AND TEAM

As with any project of this type and size, a construction team was initially identified and organized. As the Prime Contractor, ARCADIS solicited and reviewed bids on behalf of the client, Tierra Solutions, Inc. (Tierra), to conduct various portions of the work. Additionally, because the Phase I Removal Action was implemented as a design-build project, the primary subcontractors were involved with, and provided input on, their components of the final design. The primary subcontractors and their roles are detailed at the end of this article.

Additionally, as a part of the engagement strategy with the community, ARCADIS and its subcontractors provided jobs on the project to 14 unemployed local residents under the U.S. Environmental Protection Agency (USEPA) Superfund Job Training Initiative (SuperJTI). The residents were screened, selected, and trained through a rigorous program prior to commencement of dredging in March 2012. The program was viewed widely by the USEPA and project team as highly successful. It provided valuable training and experience to the participants, motivated employees to the project team, a critical connection to the project for the local community, and permanent employment to a number of the residents.

Health and Safety Program

A proactive and consistent health and safety program was critical to the overall successful implementation of the project. Through the use of and training of all site personnel in a behavior-based safety system, the team focused on the proactive identification of hazards through job safety analysis, safe work observations, Stop Work Authority (SWA), and near loss identification and reporting. Under SWA, every worker was empowered and responsible to identify potentially unsafe situations or processes and stop work until the problem was corrected. All of the trainees signed an SWA Poster to show commitment to the policy. The second important element of the health and safety program was the use of the one team approach. Using a single safety program provided a consistent framework for implementing and tracking health and safety. The program was designed to proactively identify hazards and modify worker behaviors and to encourage everyone to share accountability and responsibility for safety.

CONSTRUCTION AND OPERATION

Project Schedule

The project was scheduled to be completed in approximately 18 months (Figure 1). Because of the effective design and agility in responding to construction challenges, dredging, sediment processing, backfilling, and removal of the enclosure were completed ahead of schedule.

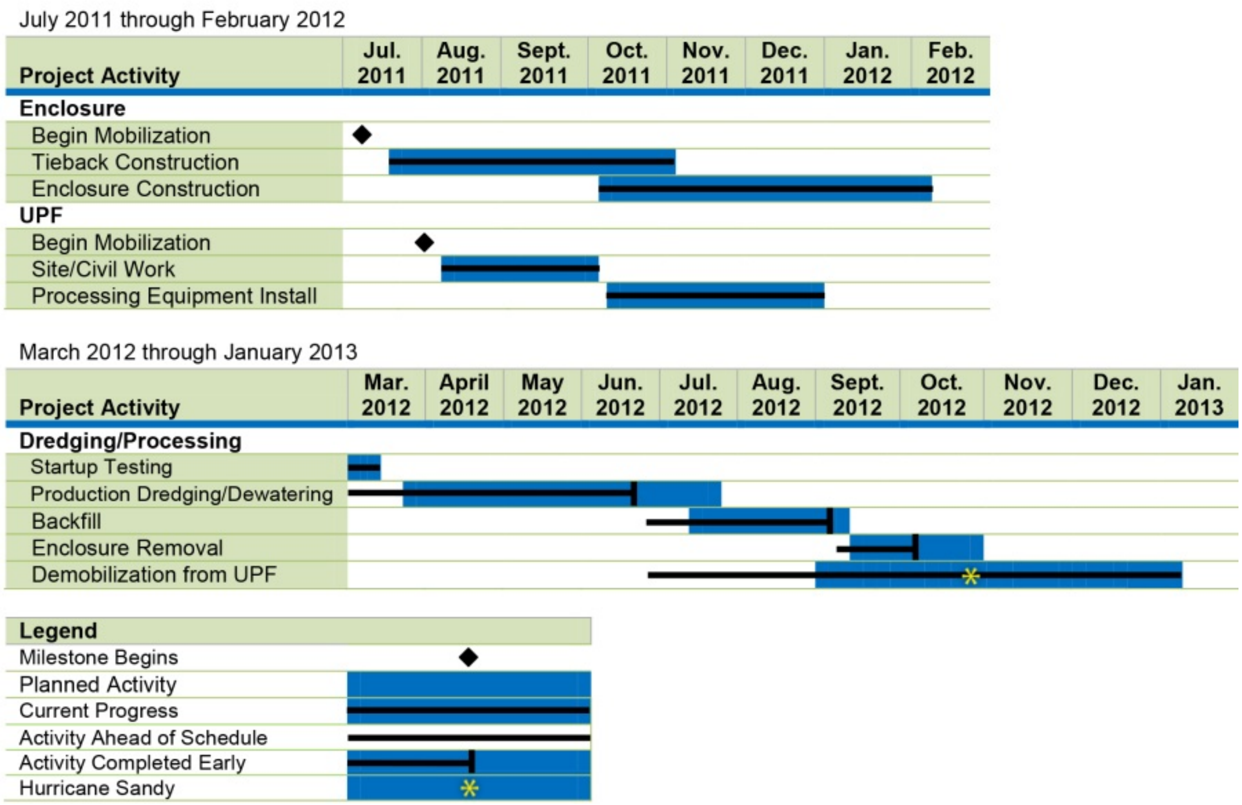

Figure 1. Project Construction and Operation Schedule

Mobilization

Mobilization was conducted in a phased manner to accommodate Upland Processing Facility (UPF) landowner negotiations, material and equipment availability, and seasonal considerations (e.g., impact of winter weather on productivity), with the overall operational objective to begin dredging in March 2012. Tieback installation and enclosure construction were scheduled to commence in July 2011, with site preparation activities to follow at the UPF in August 2011. Prior to July 2011, materials and equipment supporting the installation of the enclosure were temporarily staged at an off-site location and barged to the site when needed.

Because construction occurred in-river and the enclosure approached (but did not enter) the navigation channel, various signs and aids to navigation (e.g., buoys, delineators, and markings) were installed prior to actual installation. In addition to signage, a U.S. Coast Guard Notice to Mariners was issued to warn mariners of the Phase I Removal Action in-river activities. The OU-1 upland site (also known as the Diamond Alkali Superfund Site) was used for installation of tiebacks, treatment of tieback fluids, and offloading of dredged debris from the enclosure following improvements to the existing one-way road extending around the OU-1 environmental cap. The selected location for the UPF was leased property located at 117 Blanchard Street in Newark, New Jersey.

Competing users of resources along the river can affect remediation operations and plans. Enclosure construction was unexpectedly delayed due to a bridge closure between the Phase I Work Area and material storage area. The Lincoln Highway Bridge (downstream of the site) was undergoing repairs, rendering the lifting mechanism on the bridge inoperable. An extension to the bridge construction permit caused a 2-month delay in transporting construction materials and equipment via barge to the Phase I Work Area. With dredging not scheduled to start until March 2012, the bridge closure caused a delay in the construction of the enclosure, but not in the overall project schedule. As demonstrated by this example, relying on barge transport requires an understanding of the limitations of waterborne transportation and accommodations for other users of the river.

Combination Wall Enclosure

Tieback Installation

Direct structural support to the existing OU-1 Floodwall was provided during dredging and backfill using a row of cable strand grouted tieback anchors (tiebacks). The installation of the tieback component required drilling through the floodwall into the medium-dense to dense sand underlying the engineered cap and contained fill of the OU-1.

Tieback casings were installed at approximately 30 degrees down angle from horizontal and advanced to approximately 26 meters (m). The design load for each tieback was approximately 670 kiloNewtons (kN). Each tieback was post-tensioned to approximately 400 kN prior to sediment removal. Tiebacks were installed before the enclosure was constructed along the OU-1 Floodwall. The tiebacks were installed from land (OU-1 upland site) rather than from the water to avoid delays and challenges associated with working on marine equipment and tidal fluctuations.

The lower portion of the enclosure wale was installed using a 32-metric-ton crane from OU-1. After installation of the lower portion of the enclosure wale, coring through existing concrete, steel sheeting, and former timber bulkhead piling began to create the hole for tieback drilling. After each cored hole reached soil behind the former timber bulkhead, a plastic cap was placed to temporarily seal the hole, and the remainder of the hole was drilled using the tieback drilling equipment. Following coring, the upper portion of the enclosure wale was installed.

An excavator-mounted drilling rig positioned near the OU-1 Floodwall was used to install the tiebacks (see Figure 2). The drilling crew worked from a mobile manlift from the OU-1 upland site that allowed workers to directly access and observe individual tieback locations in front of the OU-1 Floodwall. Tiebacks were installed by drilling a 15.2-centimeter hole, fully cased, using duplex drilling methods to provide primary containment for spoils generated during drilling and grouting of tieback anchors due to over-water construction.

Because the locations of the tiebacks on the OU-1 Floodwall required drilling through the floodwall into the subsurface beneath the existing OU-1 remedial cap, the tieback hole was separated from the surrounding soil using a casing, which allowed for recovery of drilling fluids and cuttings at the drilling head and subsequent management (solids) and treatment (fluids). Once in place, the casing was flushed out to allow for a seven-wire strand tieback installation and grouting. After completion, the tieback anchors were proof-tested (i.e., loaded) to 1.3 times the design load. The tieback anchors remain a part of the OU-1 Floodwall after construction.

Resuspension and Scour Controls

Activities that disturb sediments could potentially resuspend contamination and cause impacts to the surrounding environment. Resuspension and scour of sediments outside of the sediment removal area were reduced through the use of several engineering controls, including the placement of a sand layer prior to pile driving. The approximately 15.2 centimeter (cm) thick sand layer acted as a buffer, reducing resuspension and scour of sediment during combination wall installation. Resuspension was also controlled by slowly lowering combination walls into the sediment surface using a template and avoiding repeated repositioning. Additional scour protection components, including geotextile and articulated concrete armor mattresses (see Figure 3), were placed in adjacent areas of the river after the enclosure was installed. The armor mattresses and geotextile were positioned over the river bottom using a barge-mounted crane and spreader bar. Gaps between the enclosure and the articulated concrete mattresses were filled with sand bags lowered from a work barge in a continuous, side-by-side fashion.

Enclosure Installation

A combination wall was constructed to help satisfy specific Remedial Action Objectives. The combination wall was selected due to the structural/geotechnical requirements, which exceeded a traditional cantilevered sheet pile wall. It was selected over alternatives such as a laterally supported sheet pile wall due to constructability considerations. The high capacity and ability to provide the necessary support as a cantilevered system were the primary factors in selection of the HZM combination wall system. As required by the USEPA to contain potential resuspended sediments, the water-tightness of the enclosure was enhanced using seal welds and hydrophilic sealant installed by the fabricator, prior to bringing the material to the site.

Figure 2. Tieback installation

Figure 3. Setting concrete mattress into place

The enclosure combination walls, composed of 19 m long HZ880MA-12 king piles and 10.7 m long AZ-13-770 sheet piles, were installed from the river using barge-mounted cranes and vibratory hammers initially (Figure 4). The enclosure was installed using a pre-fabricated steel frame template structure. The template was sized to accommodate nine king piles per setup and consisted of the steel frame attached to support piling driven into the subsurface. Based on a debris survey, no major obstructions were expected in the enclosure alignment. Contingency measures were identified such as using alternate pile driving methods (e.g., impact hammer) or adjusting the alignment. Some extra piling was purchased to account for this potential. No major obstructions were encountered during enclosure installation.

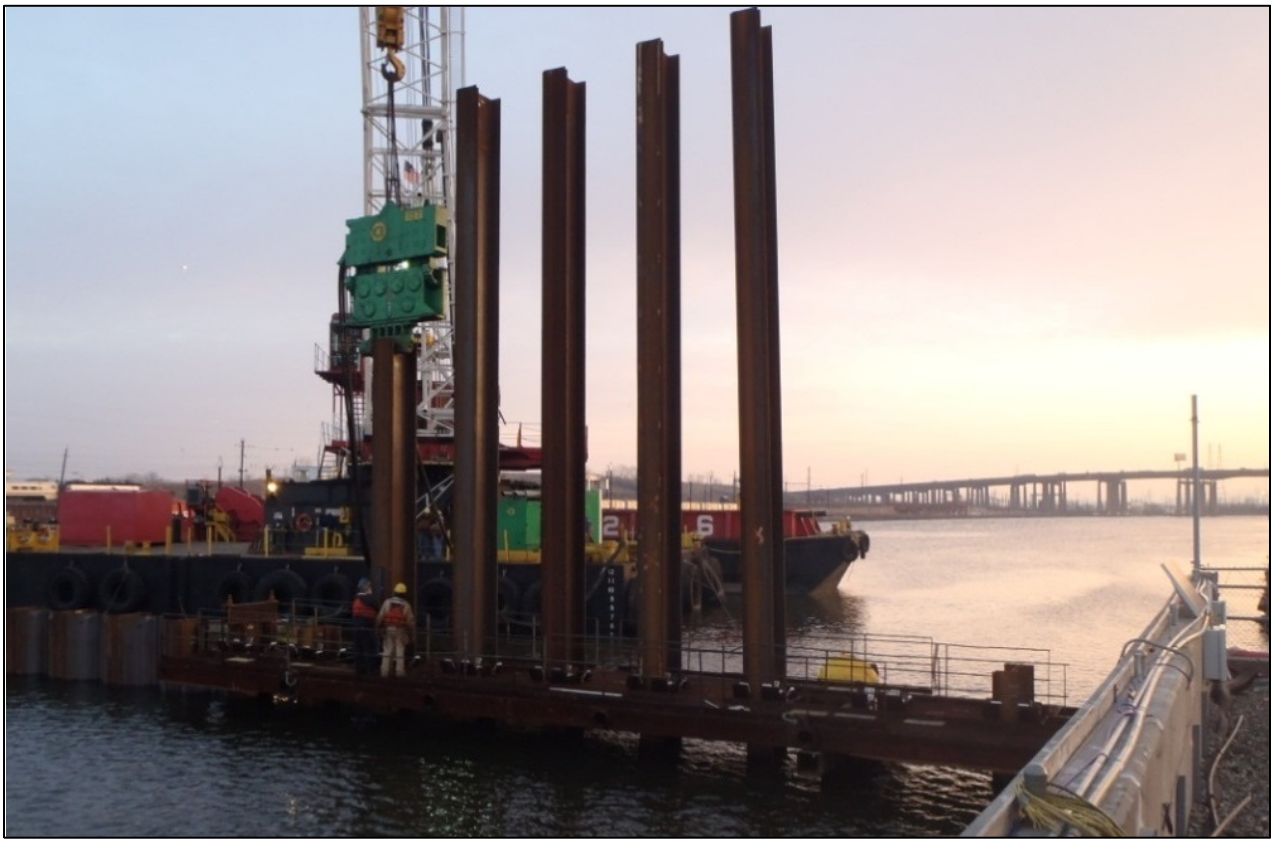

Figure 4. Installation of enclosure king piles

Sediment removal vessels were moved into the Phase I Work Area prior to completing the combination wall. Smaller vessels and equipment were lifted into the enclosure using a crane positioned outside the enclosure. Figure 5 shows the completed enclosure.

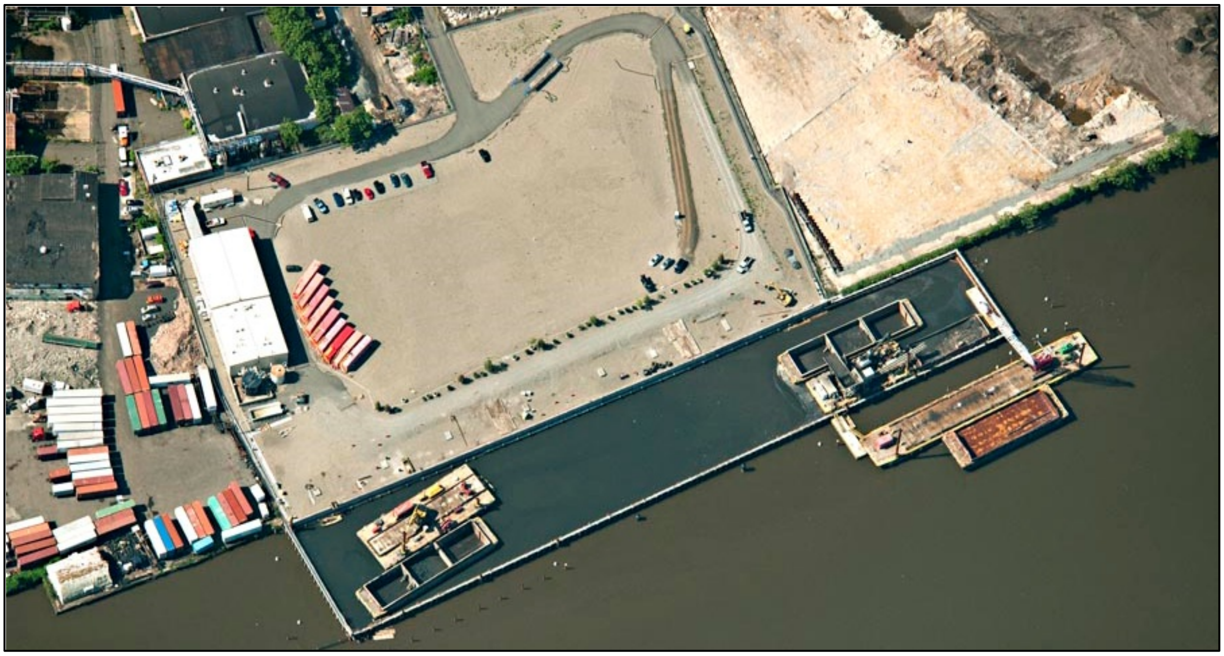

Figure 5. OU-1 and enclosure area

Ancillary Structures Installation

The ancillary structures (enclosure wall and wale supports, weir gate, walkway, steel dolphins, and pipe monopiles) associated with the enclosure design were installed at various points prior to, during, and following enclosure wall installation. Prior to enclosure installation, a single pile support for the bulkhead along the adjacent eastern property was driven. The enclosure wale and wale supports, weir gate, and walkway were installed concurrently with the enclosure. These were installed using deck barges for material staging and a crane-mounted barge to lift the components into place. Steel dolphins were installed outside of the enclosure through pre-fabricated voids located in the armor mattresses to facilitate pile driving, and fenders were placed on the dolphins. A steel piling system was deployed along the perimeter of the enclosure to reduce the risk of vessel collisions with the enclosure.

Ice accumulation was accounted for in the design as a contingency item. The Contractor was prepared to install and maintain an air bubbler system (or similar), which is used to prevent ice from forming against the enclosure walls. Ice floe impact was mitigated using perimeter monopiles. The enclosure was temporary and has been removed, so future problems from ice are not applicable. Preventive measures were planned to keep significant ice accumulation from expanding against the enclosure from inside; however, due to a mild winter, ice accumulation was minimal. Enclosure construction concluded with the completion of ancillary structures in February 2012.

Upland Processing Facility Construction

The UPF had existing environmental impacts including soils contaminated with dioxins, hexavalent chromium, and volatile organic compounds (VOCs). The excavated UPF soil materials were segregated for reuse or disposal based on concentrations of hexavalent chromium and VOCs. A geotextile demarcation layer was placed on the existing ground surface prior to placing fill. Because dioxins and VOCs were also constituents of concern (COCs) for the Phase I Removal Action, it was important to differentiate between what was already at the UPF site and what may have resulted from the sediment processing operations. Surrogate sample locations (consisting of clean sand) were installed prior to constructing the asphalt and concrete surfaces to provide data that would demonstrate the effectiveness of the concrete and asphalt pads and careful operations in preventing the Phase I Removal Action operations from impacting the UPF soils.

The UPF also had relatively poor soils with low bearing capacity, which required construction of robust foundations and monitoring for differential settlement during construction. For example, the sediment processing gravity thickener required a substantial foundation. During site preparation activities, another challenge was an unusually high amount of precipitation. Excessive precipitation had the potential to delay construction, required management of significant amounts of stormwater, and necessitated frequent dewatering of excavation areas. Through the use of additional crews and effective construction sequencing, the subcontractor demonstrated tremendous flexibility to meet the demands of the construction schedule under these adverse conditions.

Sediment Removal

Pre-Removal Activities

Removal equipment was mobilized and barged to the Phase I Work Area in preparation for beginning the sediment removal work. A multi-beam bathymetric survey conducted prior to installation of the enclosure established the pre-removal surface elevations. During mobilization, the real-time kinetic digital global positioning system (RTK-DGPS) and the necessary sensors to enable accurate horizontal and vertical positioning of the dredge bucket were installed and calibrated. The dredge bucket had a positioning tolerance of plus or minus 5.1 cm vertically and plus or minus 7.6 cm horizontally. The RTK-DGPS for the dredge was verified in the field prior to use and calibrated frequently during removal.

Mechanical Removal Operation

Following pre-removal activities, operations commenced at the Phase I Work Area. Removal operations were performed 12 hours per day, 6 days per week. An average production rate of 382 CM per day[19] was maintained, resulting in a removal duration of approximately 14 weeks. An excavator equipped with a 3.8 CM level-cut clamshell bucket was used to remove sediment (Figures 6 and 7). The excavator was mounted on a deck barge using spuds for anchoring. The barge was positioned within the enclosure using a workboat.

Sediment was removed systematically according to the defined dredge units. Due to the differences in disposal requirements of the material designated as EM for direct Subtitle C disposal and HAZ material designated for incineration prior to Subtitle C disposal (See "Sediment Removal" Section of the Design Paper), sediment removal and processing contractors closely coordinated transitions

[19] Processing throughput was dictated by offloading of the dredged sediment barge at the screening and slurrying barge within the enclosure prior to hydraulic pipeline transport to the UPF.

between dredge units of different waste designations. Removal activities were halted during these transitions. Before removal operations could continue, the pipeline used to transfer sediment was cleared by pumping river water through the pipeline, and the tanks within the sediment processing system were drawn down to mitigate the risk of mixing different material types. Once the system was cleared, dredging and processing resumed.

The removal design called for six transitions between EM to HAZ material during the dredging sequence due to the layering of the different types of material. After dredging began, and once the characteristics and behavior of the dredge material were better understood (the way the equipment was able to manipulate it, and how it handled), two of these transitions were eliminated by consolidating the removal of multiple layers of HAZ material, which allowed the team to shorten the overall dredging schedule.

Vertical bucket control at the base of each dredge unit was maintained across the dredge prism to achieve the design removal elevations while avoiding over-dredging into the deeper dredge unit. Vertical bucket control was monitored during removal operations using a combination of methods. The accuracy of the RTK-DGPS system was verified daily for normal removal operations and more frequently when near the boundary of EM and HAZ dredge units. This verification consisted of placing the clamshell bucket on a point of known elevation, such as the water surface, to confirm that the TrimblePRO® software was accurately calibrated. At the same time, staff monitored the excavator operator to provide additional oversight during the most critical removal operations. When working at the interface of a HAZ cell and EM cell, the HAZ material was removed conservatively, allowing some overdredge into the EM cell. As a result, there was an increase in the tonnages of HAZ material transported and treated in comparison with the HAZ quantities estimated during design. The design included a 0.3 m overdredge depth across the bottom of the removal area but did not account for conservatively dredging HAZ cells into deeper EM units.

Figure 6. Level-cut clamshell dredge

Figure 7. Dredge placing sediment into barge

When the removal surface was within 0.3 m vertically of the next deeper dredge unit, an interim survey was performed. The design called for bathymetric survey, but was changed to manual soundings that proved to be as effective without the delay of mobilizing a survey boat to the enclosure, dealing with potential interference in the survey from the metal enclosure and equipment, and access restriction and construction delays associated with putting another vessel inside the enclosure. After removal operations were completed, a detailed manual soundings survey was performed to confirm that the required removal elevations had been achieved. Manual soundings were collected with a surveying rod. During the initial lift, the single-beam and manual rod methods were compared to confirm that the manual method would provide a sufficient degree of accuracy.

Debris Handling

Debris was generated in two separate processes during dredging. Larger oversized debris was individually lifted out of the dredge prism using the dredge bucket and set on the designated debris barge. Debris larger than 10 millimeters that was not removed using the dredge bucket was removed by the grizzly screen and trommel screen, and a conveyor transferred it to the debris barge. Debris also included materials that did not pass through the grizzly screen and needed to be removed from the top of the screen.

A large concentration of oversized debris (ranging from small metallic debris, such as nails and bolts, to larger pieces up to 6 inches long) was encountered while dredging a HAZ material dredge cell along the OU-1 Floodwall. The concentration and size of this debris clogged the trommel screen, and the handling of this material significantly reduced productivity. A grapple was mobilized to collect the debris and bypass the screening operation. The debris quantity caused additional complications for transportation and disposal because it could not be incinerated due to its size. A debris washing operation, composed primarily of mechanical equipment, static screens, and high-pressure water, was established at the UPF site to separate sediments from the oversized debris. Debris washed during this operation was disposed of at a Subtitle C landfill. Figure 8 below shows washed debris awaiting transport. The debris washing operation proved to be a cost-effective solution to manage the disposal of oversized debris.

White phosphorus, a highly reactive material, was encountered in multiple HAZ dredge cells along the OU-1 Floodwall, resulting in temporary work shutdowns and necessitating immediate mitigation measures to address fire and inhalation hazards. White phosphorus self-combustion events varied from small areas of smoldering material to open flames on the barges. Pre-design investigations included screening for white phosphorus with no positive indications of its presence. However, historical observations of white phosphorus at OU-1 suggested it may be present within the Phase I Work Area. Based on this knowledge, staff responded quickly and safely managed the response during construction. The washing operations established for the large debris was also beneficial for this material. During the debris washing operations, materials observed containing white phosphorus were separated and temporarily stored in steel drums filled with water for eventual off-site disposal.

Figure 8. Washed debris awaiting transport

Figure 9. Debris removed from the pipeline

Hydraulic Pipeline Construction and Operation

High-density polyethylene (HDPE) pipes were used for the carrier and containment pipeline. The floating section of the pipe consisted of one length of welded pipe between the enclosure and the UPF (Figure 10). A pontoon was used to transition the pipeline to the UPF. The HDPE pipe was welded at the UPF using a butt fusion welder, and the pipe welds were water tested for leaks prior to being deployed. The pipe was then extended upriver along the south bank of the Passaic River. Pipe installation in the Passaic River was assisted by a barge, and construction continued upriver (east to west) until the pipe reached the enclosure. To secure the pipe to the river bottom, anchors consisting of pipe piles driven into the sediment were attached to the pipeline with chains approximately every 76 m along the pipeline route.

Although the hydraulic pipeline was designed to transport sediment material from the Phase I Work Area to the UPF, it was also used to convey water from the water treatment system back to the enclosure for water level management and other appropriate re-use purposes. During operations, pressure levels, flows, and pump effort within the pipeline were closely monitored. Pressure losses indicated potential blockages, which could have resulted in difficult repairs and costly delays. In fact, it was observed that the trommel screen would occasionally allow long, thin debris (e.g., thin-diameter metal rods and nails; see Figure 9) through, which could accumulate and hang up in the pipeline. Additional measures were taken to prevent blockages, such as periodically backwashing the line and adjusting the flow. The pipeline velocity, density, and pressure were continuously monitored. The pipeline was also visually inspected daily from the water. The pipeline worked well during the project, as it allowed the efficient two-way conveyance of water and sediment between the Phase I Work Area and the UPF, and no leaks or releases occurred during pipeline operation. Inspection of the pipeline upon completion of work activities indicated that minimal wear and tear had occurred on the pipeline material.

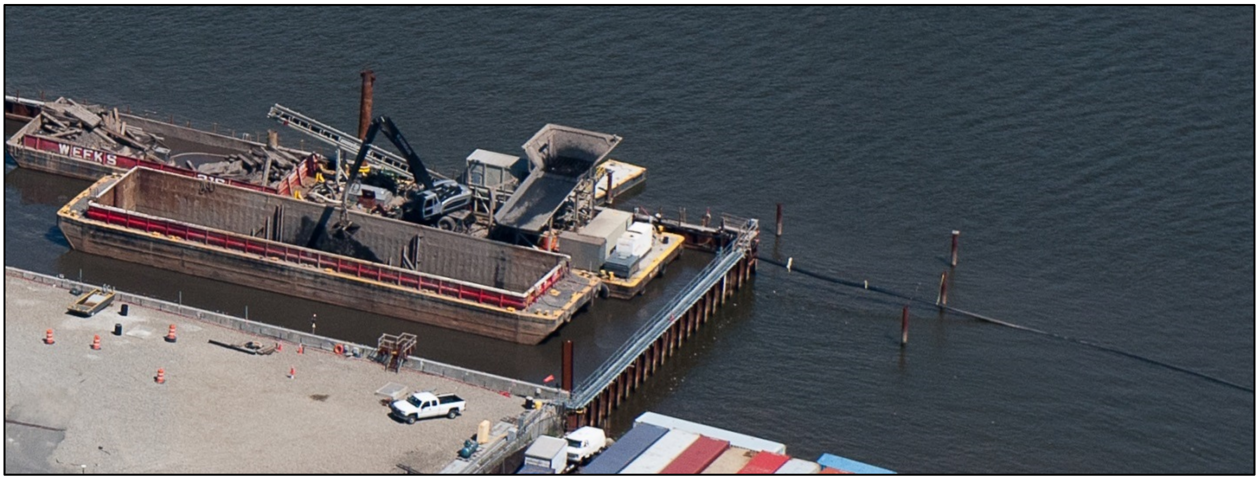

Figure 10. Pipeline leaving enclosure and Phase I Work Area sediment processing equipment

Sediment Handling and Processing Construction and Operation

The sediment-processing contractor was part of the design team, which enabled an effective transition to construction and subsequent operations. For construction of the sediment processing system, equipment and materials were obtained from several suppliers and transported from multiple locations. Equipment for the screening and pumping activities within the enclosure at the Phase I Work Area consisted of existing and modified containerized units (Figure 10). These parts were transferred to the Phase I Work Area via the river and lifted over the combination wall by a crane onto the sediment handling and processing barge. The processing equipment located at the UPF included size separation units, screening units, thickened sludge holding and storage tanks, the gravity thickener, and the MFPs (see Figures 11, 12, and 13). This equipment was installed at the UPF using a combination of mobile cranes, man-lifts, forklifts, and other tools held in a temporary workshop. A control room was installed on the barge at the Phase I Work Area and at the UPF. The data from processing operations at the Phase I Work Area were linked to the UPF control system. Finally, the pipeline feed pump was connected with the pipeline.

Figure 11. UPF sediment processing equipment aerial

Figure 12. Gravity thickener

Some challenges were encountered with peripheral components of the sediment processing system. Initially, the weighing stacker/conveyance system used to load the filter cake from the MFPs to the intermodal containers spilled some material in the container loading areas and provided inconsistent weight measurements. Startup adjustments included modifying the directional discharge chute for a consistent capture of the material onto the conveyor and modifying operation procedures to increase the frequency of cleaning and zeroing the conveyor. These adjustments significantly improved the precision and accuracy of weights provided by the conveyor system. Load weights within 4 percent of the target weights were achieved consistently through the project after the startup adjustments were implemented.

The handling of coarse solids required a post-startup supplemental process. Periodically, large quantities of wet organic material (e.g., leaves) would be removed from the shaker screen and the hydrocyclone accompanied by free liquids, making this material unsuitable for off-site transportation without further processing. The solution for this issue was to place the coarse solids into roll-off boxes with drains and lined with filter fabric in lieu of the water-tight intermodal containers. The materials were allowed to sit in these boxes, and the liquids drained from the boxes were captured in the stormwater management system and subsequently treated.

During operations, the MFPs worked exceptionally well and consistently achieved solids in the mid-60 percent level and higher, which significantly exceeded the design target (based on treatability testing) of 57.5 percent (range of 58 to 73 percent) solids, resulting in a significant reduction in disposal costs.

Figure 13. MFPs installed at UPF

Water Treatment and Discharge System Construction and Operation

Process water from the sediment processing system consisted of river water used for slurrying sediments, pore water from sediments, and other water added to make up the polymer. The water treatment system treated process water and stormwater from the UPF to meet the project requirements for discharge to the Passaic River. The water treatment system consisted of coagulation, clarification, multimedia filtration (MMF), and granular activated carbon (GAC) adsorption. The temporary water treatment system equipment and materials were obtained from several vendors, and most of the equipment was skid- or trailer-mounted. The equipment was placed on the prepared asphalt foundation or new concrete pads and anchored into place. In addition, an outfall was constructed, which consisted of a 20 cm HDPE pipe, weighted, and submerged beneath the surface of the Passaic River.

Water Treatment Operation and Monitoring

Operation of the water treatment system was divided into three separate phases: startup, continuous steady-state operation, and batch-mode waste-type transition. Startup included mechanical startup and initial startup; each took approximately 1 week to complete. Mechanical startup included leak and pressure testing, and testing of equipment and controls to confirm that the system was functioning properly. The objective for initial startup was to collect compliance samples after treating representative water from sediment processing to confirm that the water treatment system met discharge limits before discharging treated water to the river. During the initial startup period, the water treatment system was operated on a batch mode, consisting of alternating periods of water treatment and pumping and discharging water back to the enclosure through the hydraulic pipeline. Discharge to the river only occurred after sampling confirmed that discharge requirements had been met. To maximize the performance of the polymer and extend the life of the GAC media, a coagulant (ferric chloride) was selected during initial performance testing and added to the water treatment process in accordance with the design (which provided for use of a coagulant if needed).

Following successful startup, the water treatment system operated continuously on the same schedule as sediment processing: 24 hours/day, 6 days/week with exception of the subsequent batch-mode waste-type transitions. The water treatment system design flow rate was higher during the day (3,100 liters per minute [Lpm]), when the gravity thickener was operating in sediment processing, than at night (1,300 Lpm). The influent and transfer pumps were equipped to process water at maximum capacity during the day and to process water at a lower flow during the night. Variable flow rates were needed to deliver continuous water flow to the clarifier. The equalization tanks provided sufficient volume to balance flow variations. Treated water was stored in three water tanks for reuse as backwash for the MMF vessels, polymer makeup water, or wash-down water in the sediment processing area.

Because initial startup occurred during processing of EM material, and the HAZ material would produce process water containing higher contaminant concentrations, the water treatment system was returned to batch-mode operation. Discharge of treated water to the enclosure during the first transition from EM to HAZ material confirmed that the higher influent contaminant levels were successfully treated and that the water treatment system met discharge limits before discharging treated water to the river.

Daily process monitoring and required compliance monitoring were conducted. Heterogeneity in the physical and chemical characteristics of the sediment resulted in variations (e.g., concentrations of VOCs or suspended solids) in the process water (water treatment influent). This required constant monitoring of both the sediment processing and water treatment systems.

Transport, Treatment, and Disposal Construction and Operation

Equipment related to transport, treatment, and disposal (TTD) operations included:

- Intermodal containers
- Scaffolding to facilitate sealing and tarping of containers
- Sorbent materials to absorb free liquids from debris and coarse solids during transport

At the UPF, containers were filled with filter cake and coarse solids using conveyors with weighing devices. At the OU-1 upland site, containers were directly loaded with debris using long-reach excavators. While the containers are relatively water-tight, sorbent material was added to the containers containing coarse solids and debris as necessary to manage free liquids during transportation. Full containers (Figure 14) were staged in the transload area at the UPF until they were transported. Dedicated trucks operated continuously, exchanging empty containers from the transload facility with full containers from the UPF. Filling weight was monitored by the truck driver based on professional judgment and verified using a trade-certified truck scale at the transload facility. The TTD subcontractor inspected full containers to verify that they matched the waste profile description and the waste manifest, then sealed the 6-mil polyethylene liner, and secured the soft tarp cover.

Figure 14. Filter cake loaded into intermodal container

HAZ material was sent by rail to a transfer facility in Utah where it was transferred onto truck-driven chassis and transported to the Incinerator. The contents were processed through the incinerator, and the ash was disposed of at a nearby Subtitle C Landfill. EM material was transported by rail to a transfer facility in Oklahoma or Utah, where containers were transferred onto tractor-driven chassis and transported to a nearby Subtitle C Landfill. The TTD subcontractor tracked waste, including tracking each rail flat car through each major rail hub, tracking the containers throughout the transport and disposal process, and tracking the status of waste manifests and certificates of disposal.

Backfill Operation

Backfill was placed from approximately 3.7 m below the original grade (i.e., bottom of Phase I Removal Action depth) up to the pre-Phase I Removal Action elevation. The design included removal or decontamination and re-use (unlikely) of the armor mattresses outside of the enclosure, which were used for scour protection. However, during construction, USEPA suggested and approved placement of the armor mattresses at the base of the removal area. Following placement of the armor mattresses, an initial lift of backfill was placed in a slow, controlled manner with the operator placing the bucket near the sediment-water interface and releasing material slowly to avoid entraining the underlying sediment into the backfill. Production backfilling then commenced. Placement of the armor mattresses did not reduce the volume of backfill material, but did eliminate the need to manage and dispose of the mattresses and assisted in reducing resuspension and mud during placement of the first backfill lift.

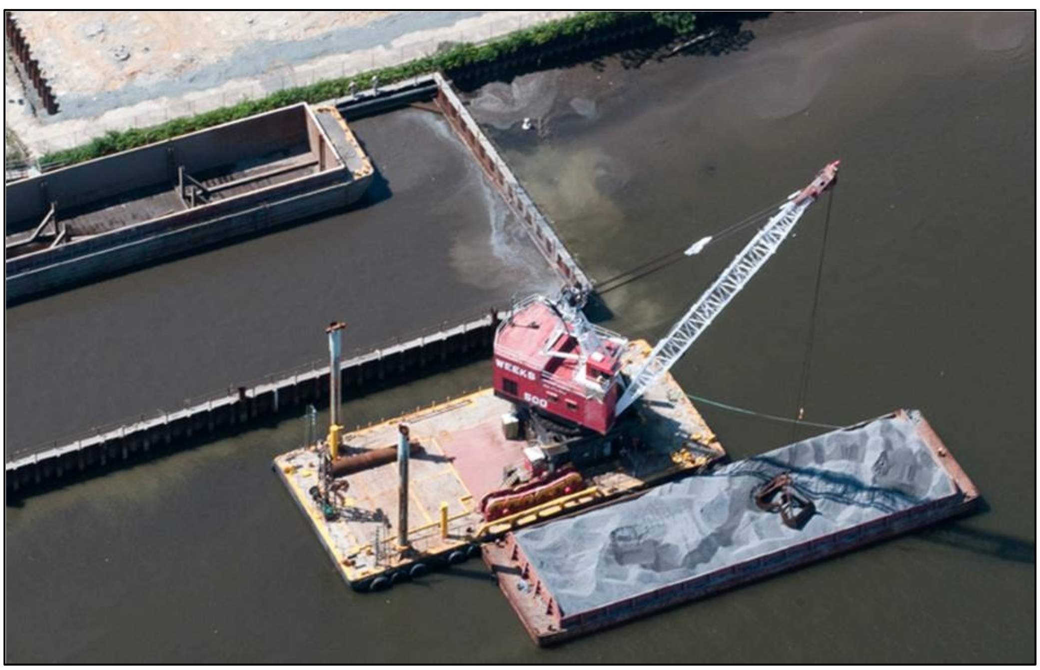

Figure 15. Backfill operations in process

Backfill material was delivered directly from the backfill supplier to the Phase I Work Area on barges as needed to sustain the backfill production rate and avoid delays in backfill placement. Backfill was placed using a clamshell bucket suspended from a crane. The bucket delivered material over the sheet pile wall into the enclosure (See Figure 15). Prior to delivery of imported material, the physical and chemical characteristics were verified to comply with the design specifications. The backfill was placed as designed without deviations to the pre-Phase I Removal Action elevation. A combination of bathymetry surveys, manual soundings, and RTK-DGPS-equipped controls were used to track and adjust backfill placement activities.

Air Monitoring

Air monitoring was conducted for on-site health and safety, as well as for perimeter monitoring of dust and volatile constituents. As described in the companion paper, numerous controls were employed to control dust, volatile constituents, and odors. Air monitoring results at the perimeter indicate that these controls were successful, with only a single reading from one of nine perimeter monitoring stations reaching the USEPA concern level (lower than the USEPA action level) over the course of dredging and processing activities.

During transition to the first HAZ material cell, worker safety air monitoring indicated VOC levels above action levels, which warranted a respiratory upgrade to Level C protection (air-purifying half-face and full-face respirators). As a result, Level C respiratory protection was instituted at the beginning of the following HAZ material cell, and monitoring results were used to indicate when the protection could be downgraded. Although hydrogen sulfide (H_2S) was a potential concern due to dredging in a marine environment, and monitoring and contingency controls were readily available, hydrogen sulfide was not an issue during the project.

CONCLUSIONS

Tierra worked cooperatively with USEPA and other local stakeholders throughout each phase of the project to successfully complete the Removal Action within approximately 4 years following issuance of the Administrative Settlement Agreement and Order on Consent. Project successes include completion of dredging on schedule, no recordable safety incidents over 140,000 construction labor-hours, active community engagement and local economic benefits (SuperJTI), and the MFP filter cake significantly exceeded percent solids performance criteria, thereby reducing waste quantities and costs.

The following subcontractors were instrumental in the implementation and completion of this project work:

- Weeks Marine, Inc., of Cranford, New Jersey, for enclosure construction/removal, sediment removal, backfill placement, and hydraulic pipeline construction
- Stuyvesant Environmental Contracting, Inc., of Princeton, New Jersey, for sediment screening, processing, and hydraulic pipeline operation
- Clean Harbors Environmental Services, Inc., of Newark, New Jersey, for water treatment and TTD
- Nicholson Construction Company of Cuddy, Pennsylvania, for tieback installation, post tensioning, and decommissioning
- Abscope Environmental Inc., of Canastota, New York, for UPF site development and demolition
- DPK of Middlesex, New Jersey, for professional land surveying services
- Ocean Surveys, Inc. of Old Saybrook, Connecticut, for bathymetric surveys

NOTES FOR CONTRIBUTORS

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$$y = a + b + cx^2 \tag{1}$$

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Hunt, J.B. (1995). *Environmental Dredging*. Smith & Son, Inc., New York, NY.

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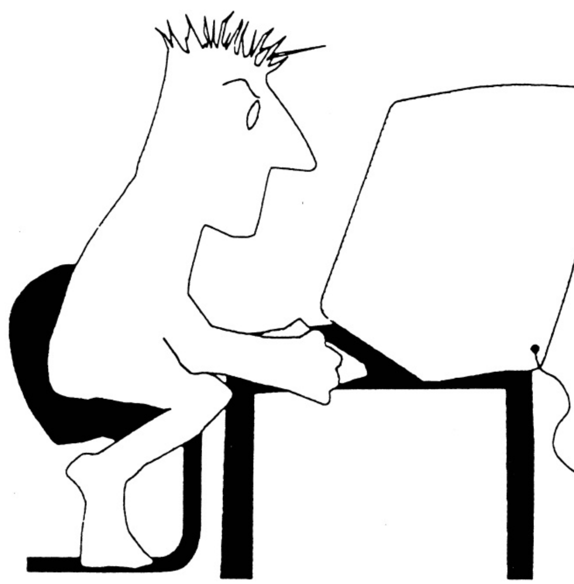

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