ABSTRACT

Dredging sediment to a depth of 3.7 metres (12 feet) below sediment surface and transporting it to a separate site for processing without increasing the volume of material and associated handling and disposal requires innovative approaches. The objective of the work is to remove sediments with the highest dioxin concentrations in the Lower Passaic River Study Area. Phase I of the Lower Passaic River Removal Project, currently underway, is being completed within a sheet pile cofferdam approximately 0.8 hectares (2 acres) in size to isolate the work area from the surrounding river and to control tidally-influenced water levels to provide adequate draft for dredging equipment. During pre-design investigations, the sediment was characterised in-situ as Environmental Media (EM; waste that does not demonstrate hazardous characteristics which can be directly disposed of at a landfill), or Hazardous Waste (HAZ; waste that requires incineration prior to disposal) to determine disposal.

The sediment is being mechanically dredged, screened and slurried, and transported through a hydraulic pipeline to an upland processing facility (UPF) approximately 0.4 kilometres (0.25 mile) downstream of the project site where it is being dewatered using membrane presses. The dredging is being sequenced to remove the sediments classified as EM separately of those classified as HAZ. Surveying and tracking techniques are being employed to track the sediments through the dewatering process to final disposal. From the UPF, the material is being transported by rail to either a landfill or an incineration facility depending on the waste classification. After dredging, the Phase I Work Area is being backfilled to grade.

Dredging started in March 2012, with production dredging beginning after a two-week startup period. Production rates are consistent with the target design rate of 382 cubic metres (500 cubic yards) per day. To date, the membrane presses are exceeding the percent solids design criteria.

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INTRODUCTION

An Administrative Settlement Agreement and Order on Consent (AOC; USEPA 2008) was entered into by USEPA, Occidental Chemical Corporation, and Tierra Solutions, Inc. in June 2008, specifying removal and disposal of 152,910 cubic metres (m³; 200,000 cubic yards [cy]) 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, at approximately River Mile 3.4. The AOC identified two distinct phases of work:

- Phase I, targeting approximately 30,580 m³ (40,000 cy)
- Phase II, targeting approximately 122,330 m³ (160,000 cy)

This article discusses the design and construction of Phase I of the work. The main objective of Phase I is to remove the highest concentrations of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) and associated dioxin mass. To achieve this objective, dredging will be
conducted to 3.7 metre (m; 12 foot [ft]) below sediment surface (BSS) within the footprint of the Phase I Work Area. The Removal Action activities are being 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 removal alternatives.

Initial Phase I construction activities, including mobilisation, construction of the steel sheet pile enclosure and preparation of the UPF, began in July 2011. Dredging began in March 2012. The construction is scheduled to be completed in November 2012.

SITE DESCRIPTION

The Phase I Work Area is located within the Harrison Reach of the LPRSA; the LPRSA is approximately 27 kilometres (km; 17 miles) 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.

The Phase I Work Area is approximately 0.8 hectares (2 acres) in size, measuring 229 m (750 ft) long by 34 m (110 ft) to 41 m (135 ft) wide. The Phase I Work Area is adjacent to a federal navigation channel with an authorised depth of -6.8 m (-22.4 ft) National Geodetic Vertical Datum of 1929 (NGVD29). The Phase I Work Area is located completely outside of the navigation channel, but approaches the navigation channel boundary at a distance of approximately 7.6 m (25 ft) at its western end. At the widest point of the Phase I Work Area, the Passaic River is approximately 168 m (550 ft) wide, and at the narrowest point, it is approximately 122 m (400 ft) wide. Generally, the Phase I Work Area sediment is fine-grained, cohesive material classified as moderate to high plasticity organic silt and clay. The average flow near the Phase I Work Area is approximately 41 cubic metres per second (1,450 cubic feet per second). The Passaic River is tidal, with about a 1.8 m (6 ft) tidal fluctuation at the project site. The Phase I Work Area is regularly exposed during low tide conditions, as shown in Figure 3.
REMOVAL ACTION OBJECTIVES

The removal action objectives (RAOs) for the Phase I Removal Action, established to determine the relative success of the work, are listed below (USEPA 2009):

• RAO #1: Remove a portion of the most concentrated inventory of dioxin (2,3,7,8-TCDD) and other hazardous substances to minimise the possibility of migration of contaminants owing 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 such.

• RAO #3: Prevent, to the maximum extent practicable, the potential for spillage or leakage of sediment and contaminants during transport to the disposal facility.

• RAO #4: Restore habitat. (Restoration of the Phase I Work Area will be coordinated with the activities of the bordering Phase II Work and will not occur until Phase II is completed.)

PROJECT DESCRIPTION

The project consists of nine distinct components which are described below: Sheet Pile Enclosure; Sediment Removal; Hydraulic Pipeline; Upland Processing Facility (UPF); Sediment Processing; Water Treatment; Off-Site Transportation, Treatment and Disposal; Backfill; and Air Emissions.

Sheet pile enclosure

Per the 2008 AOC (USEPA 2008a), removal activities are being completed within a sheet pile enclosure. The enclosure consists of 3 sheet pile walls on the west (upstream), north (riverside) and east (downstream) sides of the Phase I Work Area. The enclosure is constructed with king piles embedded to approximately 16 m (53 ft) BSS for primary lateral support and interlocking Z-shaped piles to create the continuous enclosure.

The piles are sealed to mitigate water leakage and loss of sediment through the interlocks. The fourth side of the enclosure is the floodwall adjacent to the river in front of the OU-1 upland site. Owing to the depth of the removal, the floodwall required additional structural support to mitigate the loss of passive forces provided by the sediment, which was accomplished with the installation of grouted tieback anchors. Figure 4 provides a view of the completed enclosure.
The sheet pile enclosure provides sufficient draft for the barges and equipment working within it, and removes the impact of changing water levels owing to tidal fluctuation. The sheet pile enclosure also provides the necessary lateral support to complete the removal to a depth of 3.7 m (12 ft) BSS. It also satisfies RAO #2 by mitigating dispersion of resuspended sediment during dredging.

**Sediment removal**

The material inside of the enclosure is being dredged to a depth of 3.7 m (12 ft) BSS, with a 9 cm (0.3 ft) overdredge allowance. The dredge area is made up of seven distinct dredge units, with two different waste classifications: Environmental Media (EM) and Hazardous Waste (HAZ).

The waste classifications of the dredge units were determined through pre-design investigation sampling. One sample per 382 m³ (500 cy) was collected for dredge material characterisation purposes. The results of the characterisation sampling were screened against Resource Conservation and Recovery Act (RCRA) regulatory levels to determine the applicable RCRA disposal requirements for each sediment sample and surrounding sediment. Segregation of EM and HAZ material is critical to preserving the application of in-situ characterisation of the material for disposal profiling purposes. Materials are handled in accordance with the in-situ characterisation results of the dredge unit from which they were generated and segregated for disposal in accordance with those characterisation results. The dredge elevations of the dredge units are designated based on the waste characterisation of the material. In addition, overdredging is not allowed when dredging in a dredge unit designated as EM material which is underlain by a dredge unit designated as HAZ material. When the dredger approaches vertical transitions between HAZ and EM material, they have requirements to increase interim surveys and checks on the positioning equipment to ensure the dredge bucket is at the elevation it is reporting.

Prior to proceeding into a dredge unit with a different material type designation, dredging will be temporarily halted while the hydraulic pipeline is cleared and the tanks within the sediment processing plant (discussed in subsequent sections) are drawn down. This supports the dredge inventory tracking by providing an indication that dredging and processing of one type of material in one dredge unit has been completed and dredging and processing of another type of material from another dredge unit is beginning. It also provides a gap between materials of two different waste characterisations for purposes of loading transport containers.

The dredging is being conducted with a mechanical excavator fitted with a 3.8 m³ (5 cy) bucket. Approximately 30,580 m³ (40,000 CY) of in-situ material is being removed, with a design production rate of 382 m³ (500 cy) per day. The sediment is loaded onto a material barge located within the enclosure. Large debris (greater than 1.5 m [5 ft] in any one direction) is handled directly by the mechanical excavator, while smaller debris is screened out in the sediment processing step. Dredging progress is tracked using DREDGEPACK® dredge operator software, independent bathymetric surveys, manual soundings, and daily dredge reports. Figure 5 shows the dredging operations.
Hydraulic pipeline
Identifying an adequate upland processing facility (UPF) on which to construct the sediment dewatering plant and water treatment plant, as well as handle the dewatered sediment for offsite shipment, was a technical challenge. The UPF needed to have shoreline access, for conveyance of dredged material to the sediment dewatering plant; it had to be of sufficient size for the equipment and logistics associated with offsite transportation of the material; and the land had to be sufficient for the type of development necessary to handle the loads associated with the sediment dewatering equipment and tanks used for the water treatment plant. An adequate facility was identified approximately one-quarter mile downstream from the Phase I Work Area that fit the requirements. The engineering team then had to evaluate the best method 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.

The design team concluded that screening and slurrying the dredged sediment at the Phase I Work Area, and pumping it hydraulically using a pipeline to the UPF, was the most feasible and technically sound approach. Working closely with the dewatering subcontractor, Stuyvesant Environmental Contracting, Incorporated (SECI), and the dredging subcontractor, Weeks Marine, the engineering team designed a sediment screening and slurrying process, located within the enclosure, shown in Figure 6. The slurry feeds into a hydraulic pipeline floating along the shoreline between the Phase I Work Area and the UPF. The pipeline is show in Figure 7.

To get the material into the pipeline, the dredge material barge is first unloaded into a hopper fitted with a grizzly screen, followed by a trommel screen. These screens will remove debris greater than 12.7 millimeters (mm; 0.5 inch [in]). A sprayer is used to wash the material through the screens, which feed into a slurry makeup tank. A hydraulic feed pump is used to pump the sediment slurry, containing 14% solids by weight, into the hydraulic pipeline, which conveys the material at a flow rate of 3,331 liters per minute (880 gallons per minute). At the UPF, the hydraulic pipeline feeds directly into the sediment processing plant, discussed in more detail in a subsequent section.

Upland Processing Facility (UPF)
The UPF is the upland site where the sediment processing, decant water treatment and offsite transportation of the dewatered sediment (filter cake) occurs. 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 used for sediment processing and water treatment, and various components of the sediment processing plant. A pavement section analysis was also completed for the sediment processing, water treatment, and loading areas. Figure 8 shows preparation of the UPF, the installation in progress and the final facility.

Sediment processing
To reduce the disposal volume to the maximum extent practicable, mechanical membrane presses were selected to dewater the sediment. The design criteria for the target percent solids content of the dewatered filter cake is 57.5%, based on pilot testing and the capabilities of the membrane presses. Initial processing occurs at the enclosure, described previously, as a part of the slurrying process. After passing through...
the hydraulic pipeline to the UPF, the sediment slurry is passed through another screen, followed by hydrocyclones, to separate out the coarse fraction of the material (greater than 0.0762 mm [0.003 in]). The coarse fraction of the material is dewatered by vibratory screen.

Following the hydrocyclone step, the resulting fine-grained sediment slurry is mechanically dewatered using mechanical presses (membrane presses). Following separation of coarse solids, the fine-grained slurry is pumped to a gravity thickener to thicken the slurry and increase the percent solids to approximately 15%. Thickened sediment slurry is pumped from the gravity thickener to sludge storage tanks which provide a process equalisation basin for feeding the presses and temporary storage of thickened slurry to allow for 24 hr/day operation of the presses. Polymer is added to the slurry prior to the gravity thickener and again prior to the mechanical press. The thickened slurry is then mechanically dewatered using membrane plate and frame (membrane) presses. The press plates are shown in Figure 9.

Membrane presses were selected owing to their higher performance, similar lead times, and slightly lower overall cost (when factoring in operations, transport, treatment, and disposal) compared with plate and frame presses.

Membrane presses are similar to standard plate and frame presses, but have an impermeable membrane in addition to the filter cloth. Half of the plates in a membrane press 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, membrane presses generally achieve the highest solids contents as a result of the membrane pressure applied.

Membrane presses also typically have shorter cycle times than plate and frame presses. Four 344 cubic foot (13 cubic yard) capacity membrane presses were used to provide capacity to dewater 500 in situ cubic yards per day. The membrane presses were designed to be modular units that can be reused for subsequent projects by the sediment processing contractor. The membrane presses (DIEMME Model GHT 1.500 P13 Overhead Beam) were built especially for the project and had a lead time of over six months.

The resulting dewatered sediment (filter cake) is placed in lined containers and the containers are sealed as shown in Figure 10. The dewatered coarse fraction is placed in lined containers and the containers are sealed.

Water treatment
A temporary water treatment system is being used to treat water being generated from a variety of site processes. The system is capable of removing contaminants from the water generated during the sediment processing activities to the permit equivalency effluent limits. The hydraulic capacity of the temporary water treatment system accommodates the flows from the sediment process effluent, multimedia filter (MMF) backwash supernatant, hydraulic pipeline flush water, and Type 2 storm water (storm water that may potentially contact Phase I sediment or untreated process water) generated from the UPF.

The temporary water treatment system consists of coagulation, clarification, multistage filtration using multimedia filter, and liquid-phase GAC adsorption. Treated effluent is discharged directly to the Passaic River or reused at the UPF as needed. Reuse is limited to polymer make-down and washing down sediment processing filter presses or equipment, provided the water is collected and treated again in the water treatment system after reuse. Samples of the water treatment effluent are collected to confirm that the discharge water to the Passaic River meets the effluent limits.

Off-Site transportation, treatment and disposal
The dredged material (i.e., debris, coarse fraction, and filter cake) is transported to, treated, and/or disposed of in a permitted treatment and/or disposal facility according to the material type designation of the dredge unit from which it was sourced (i.e., EM or HAZ), as described previously. Sediment that does not exceed RCRA regulatory levels is environmental media (EM) and is eligible for direct land disposal without any additional treatment or testing. It is disposed of at a RCRA Subtitle C disposal facility.

Sediment that is classified as characteristic Hazardous Waste (HAZ) requires treatment prior to disposal. HAZ material will be sent to a treatment facility for incineration, and the resulting incinerator ash will be disposed at a RCRA Subtitle C disposal facility. The debris and coarse fraction are classified and disposed of in the same way as the dredge unit from which it originated.

The material is placed into containers at the UPF (as shown in Figure 11) and transported via trucks to a transload facility nearby, where it is then transported by rail to the final treatment and/or disposal location.

Backfill
Following removal activities at the Phase I Work Area, including confirmation that the removal depth has been attained within the overdredge
allowance, the area within the sheet pile enclosure will be backfilled and restored to its original grade. Part of the function of the backfill is 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 must be placed to at least the pre-construction elevation.

The specified backfill material has similar physical characteristics to the in-situ sediment as practicable, but with improved engineering and structural properties, such as a lower plasticity index. In addition, it is important that the backfill material remain in place after the enclosure is removed. Excessive scour of the backfill material could result in destabilisation of the existing structures. A coarser material (D50 of 2 to 4 millimetres) was determined to be sufficient to help reduce surface scour of the backfill material after the enclosure is removed. A final bathymetry survey will be conducted upon completion of placement of the backfill material, to confirm the design objectives have been met. After this confirmation, removal of the sheet pile enclosure will commence.

Air emissions
During construction, as well as the handling and processing steps at the UPF, the potential for the generation of air emissions and odors from dredging are clearly present. To evaluate this potential, air modelling was performed. The main conclusions of the modelling of primary constituents of concern (COCs) from the Phase I Work Area are that concentrations are predicted to be below worker safety guidelines established by National Institute for Occupational Safety and Health and Occupational Safety and Health Administration. Nonetheless, additional steps, such as tarping barges, are being utilised in the Phase I Work Area. The main conclusions of the modelling of COCs from the UPF were that the major potential emissions source is the thickened sludge storage tanks. Therefore, the sludge storage tanks at the UPF are covered to reduce air emissions.

An evaluation for the potential for hydrogen sulfide (H2S) emissions was also conducted. The main conclusions of the H2S emissions rate evaluation were the estimated on-site concentration at the Phase I Work Area is expected to be lower than worker safety criteria and the estimated off-site concentrations for the nearest industrial receptor, the nearest commercial receptor and the nearest residential receptor are expected to be lower than the New Jersey Department of Environmental Protection reference concentration for short-term exposure. Although the modelling estimates H2S emissions lower than worker safety and short-term exposure criteria, H2S is monitored because of the significant risks of overexposure and because of similar estuarine sediment dredging projects where H2S was an issue.

During dredging and sediment processing activities, perimeter air monitoring is being conducted for polychlorinated biphenyls (PCBs), dichlorodiphenyltrichloroethane (DDT), dioxins, and chlorobenzene at both the Phase I Work Area and the UPF. Additionally, two nearby residential areas are being monitored.

CONCLUSIONS
The design performance to date has been evaluated as follows:
Dredging started in early March 2012, with production dredging beginning after a two-week startup period. Production rates are consistent with the target design rate of 382 m³ (500 cy) per day.

Additional debris handling considerations have been evaluated, including additional rinsing and sorting, as the debris being screened out at the enclosure is saturated with sediment and is more difficult to handle than expected in design.

Slurrying and transport of the material via hydraulic pipeline is operating as expected.

To date, the membrane presses are exceeding the percent solids design criteria of 57.5%, generally exceeding 60% solids in the filter cake. Coarse solids content has been around 10%, but is expected to increase to the design quantity of 14% as most of the coarser material was observed in discrete locations within the Phase I Work Area.

Water treatment samples and air monitoring results are within expected ranges as well.

REFERENCES
