REPORT

Preliminary Design Report
Hudson River PCBs Superfund Site

General Electric Company
Albany, New York

April 2004

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engineers & scientists

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1. Introduction

This *Preliminary Design Report* has been prepared on behalf of the General Electric Company (GE) and presents the Preliminary Design for the remedy selected by the United States Environmental Protection Agency (USEPA) to address polychlorinated biphenyls (PCBs) in sediments of the Upper Hudson River, located in New York. This *Preliminary Design Report* was prepared in accordance with the *Remedial Design Work Plan* (RD Work Plan) (Blasland, Bouck & Lee, Inc. [BBL], 2003a), and pursuant to an Administrative Order on Consent for Hudson River Remedial Design and Cost Recovery (RD AOC), effective August 18, 2003 (Index No. CERCLA-02-2003-2027) (USEPA/GE, 2003). Pre-design sediment sampling activities are being conducted under the AOC for the Sediment Sampling and Analyses Program (SSAP) (Sediment Sampling AOC), effective July 26, 2002 (Index No. CERCLA-02-2002-2023) (USEPA/GE, 2002).

This *Preliminary Design Report* was developed consistent with applicable USEPA guidance documents, including:

- *Guidance for Scoping the Remedial Design* (USEPA, 1995a);
- *Remedial Design/Remedial Action Handbook* (USEPA, 1995b); and
- *Guidance on USEPA Oversight of Remedial Designs and Remedial Actions Performed by Potentially Responsible Parties* (USEPA, 1990).

1.1 Project Setting

The Hudson River is located in eastern New York and flows approximately 300 miles in a generally southerly direction from its source, Lake Tear-of-the-Clouds in the Adirondack Mountains, to the Battery, located in New York City at the tip of Manhattan Island. The USEPA issued a Superfund Record of Decision (ROD) on February 1, 2002, calling for, among other things, the removal and disposal of approximately 2.65 million cubic yards (cy) of PCB-contaminated sediments from the Upper Hudson River (USEPA, 2002a). The USEPA divided the Upper Hudson River between Fort Edward and Troy into three sections (River Section 1, River Section 2, and River Section 3) for the sediment remediation activities outlined in the USEPA's 2002 ROD. The location of each river section is described below and illustrated on Figure 1-1:

- **River Section 1:** Former location of Fort Edward Dam to Thompson Island Dam [from river mile (RM) 194.8 to RM 188.5; approximately 6.3 river miles];
- **River Section 2:** Thompson Island Dam to Northumberland Dam (from RM 188.5 to RM 183.4; approximately 5.1 river miles); and
- **River Section 3:** Northumberland Dam to the Federal Dam at Troy (from RM 183.4 to RM 153.9; approximately 29.5 river miles).

The history of this site has been well documented in previous reports and is not repeated here. However, where appropriate, previous information on the site has been utilized and is referenced in individual sections of this *Preliminary Design Report*. One aspect of the site not specifically covered elsewhere in this report, but relevant to the Hudson River remedy, is a summary of other remedial activities related to the Hudson River, as described below.

In 2001, GE completed, under agreement with the NYSDEC, a feasibility study (FS) for the Hudson Falls plant site and recommended that the primary old manufacturing building be demolished, a cap be placed over the site, and the existing groundwater collection and treatment system be expanded. This groundwater system expansion would include the installation of approximately 2,000 feet (ft) of bedrock tunnel 160 ft below the plant, between the site and the river. The tunnel, when installed, would capture the remaining minute quantities of PCBs migrating toward the river through the bedrock fractures adjacent to the site. A final decision on this Hudson Falls remedy is expected soon from the NYSDEC. The ROD (USEPA, 2002a) indicates that this source control remedy is anticipated to be implemented before the start of the Phase 1 dredging remedy.

In addition, the NYSDEC is currently undertaking the excavation of PCB-containing soil and sediment in the area of former Outfall 004 near the Fort Edward plant site. The GE facilities, river reaches, and remnant deposits are depicted on Figure 1-2.

1.2 Remedial Action Summary

The 2002 USEPA ROD calls for the removal of an estimated 2.65 million cy of sediment from the Upper Hudson River, based on the information available at that time. The exact amount of dredging will be determined during design using the data being gathered pursuant to the Sediment Sampling AOC (USEPA/GE, 2002).

The ROD specifies that sediment will be removed from the river using environmental dredging techniques and transported by barge or pipeline to the land-based sediment processing/transfer facilities (processing facilities) for dewatering and, as needed, stabilization. It further specifies that the dewatered sediments will be transported via rail and/or barge to licensed landfills outside the Hudson River Valley for disposal. Using trucks for transporting processed material is precluded. However, the ROD permits materials destined for beneficial use to be transported out of the project area via rail, barge, or truck. Backfill material may be transported via rail or barge. The potential beneficial use of dredged material will be evaluated during design.

The USEPA has developed draft performance standards (Engineering and Quality of Life) for the project. For Engineering Performance Standards, the USEPA has developed draft standards for production rates, PCB resuspension, and PCB residuals in post-dredge surface sediments. These draft standards are currently undergoing independent peer review and are further discussed in sub-sections 2.1.1 and 4.1. The USEPA just recently released the draft Quality of Life Performance Standards (addressing air quality, odor, noise, lighting, and navigation) for public comment (see sub-sections 2.1.2 and 4.2). In addition, the USEPA will select and acquire the land-based processing facilities needed for sediment processing and material loading prior to transport.

In July 2002, GE entered into the Sediment Sampling AOC with the USEPA (USEPA/GE, 2002), and undertook an extensive sediment sampling program to provide data needed for the design of the remedy set forth in the ROD (USEPA, 2002a). Results from this sampling program will be used to determine the areas of the Upper Hudson River that require dredging. In all, approximately 30,000 sediment samples from the Upper Hudson River will be collected under the post-ROD sampling program. In August 2003, GE entered into the RD AOC with the USEPA (USEPA/GE, 2003).

The 2002 ROD (USEPA, 2002a) calls for the dredging to be undertaken in two distinct phases – Phase 1 and Phase 2. Phase 1 is defined as the first year of the project, in which sediment removal will be conducted at a reduced rate (with at least 30 days at full-scale production) to test whether the established performance standards can be achieved. At the end of Phase 1, the USEPA will perform an evaluation of the project and an independent scientific peer review will be conducted.

Phase 2 dredging will be designed to complete the project in 5 additional years. The proposed USEPA productivity standard (Malcolm Pirnie, Inc. and TAMS Consultants, Inc. [Malcolm Pirnie and TAMS], 2003) calls for the removal of approximately 240,000 cy of sediment during Phase 1, with the remainder handled in Phase 2 (approximately 2.4 million cy of sediment based on the ROD estimate of 2.65 million cy total). The relationship between Phase 1 and Phase 2 of the project and the three steps of design (Preliminary, Intermediate, and Final), as described in the RD Work Plan (BBL, 2003a), is illustrated on Figure 1-3, below.

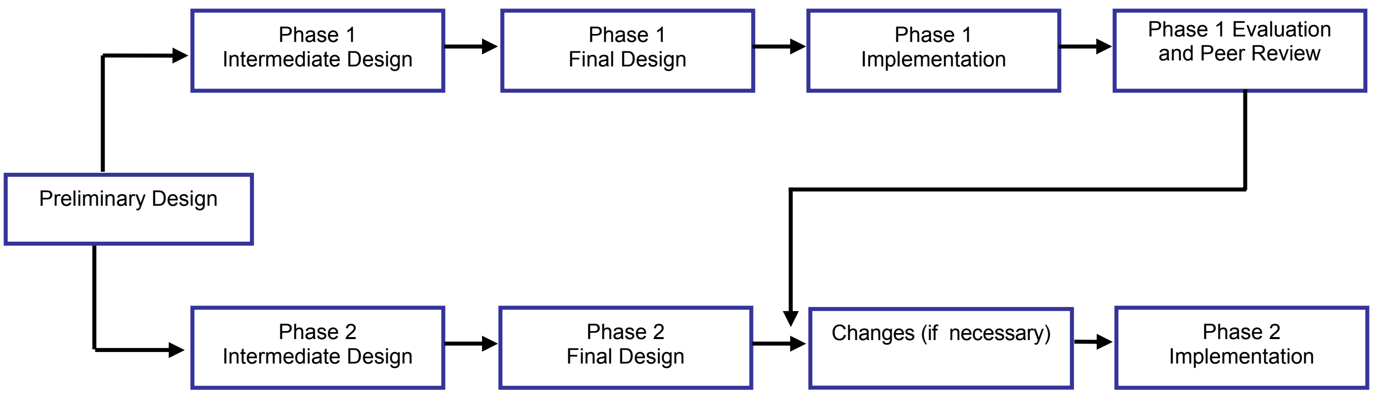

Figure 1-3 – Sequence of Design for Phase 1 and Phase 2 of the Hudson River Project

A more detailed description of the major components of the USEPA-selected remedy can be found in the ROD (USEPA, 2002a), as well as the RD Work Plan (BBL, 2003a).

1.3 Remedial Design Objectives

As stated in the RD Work Plan (BBL, 2003a), the primary objective of the RD for the Upper Hudson River is to develop plans and specifications for implementing the USEPA-selected remedy, consistent with the ROD (USEPA, 2002a), and, with the goal of achieving the USEPA-issued performance standards. In the course of doing so, the design is to ensure that the remedy is implemented in a safe and efficient manner. Finally, the design must manage uncertainty, variability, and costs associated with a sediment dredging program of this nature. No decision has yet been made regarding who will implement the remedial activities once the design is complete. This determination will be made at a later date.

Specific activities to accomplish the RD objectives, as described in sub-section 1.3 of the RD Work Plan (BBL, 2003a), include the following:

- Collect and analyze data and other information necessary to support the RD for the Upper Hudson River;
- Develop engineering and design specifications to support USEPA efforts in identifying and evaluating land-based sites necessary for project implementation, including the processing facilities;
- Design facilities to handle and process the removed sediment to prepare such sediment for transport and disposal, and treat the separated water prior to discharge back into the river;
- Design a dredging program with a total target project duration of 6 years (1 year for Phase 1 and 5 years for Phase 2), consistent with the USEPA-established performance standards;
- Develop engineering and design information to support the identification and selection of the sediment areas to be removed during the Phase 1 dredging program;
- Develop design documents for the Phase 1 and Phase 2 dredging programs with the goal of achieving the performance standards established by the USEPA;
- Develop RD deliverables to allow timely execution of the Phase 1 and Phase 2 dredging programs; and
- Develop an effective monitoring program, starting with implementation of a baseline monitoring program, to allow an assessment of the results of remedy implementation (including the monitored natural attenuation component of the remedy) relative to the performance standards and remedial goals established by the USEPA.

The specific activities to accomplish the RD objectives as described in the RD Work Plan (BBL, 2003a) have expanded to include the following additional activities:

- Delineate sediment to be removed from the Upper Hudson River consistent with the criteria in the ROD (USEPA, 2002a) and RD Work Plan (BBL, 2003a); and
- Design the system by which: 1) the dredged and processed sediment will be efficiently and safely transported by rail and/or barge from specific locations in the project area to final disposal facilities; and 2) backfill/cap material will be transported by rail and/or barge to the project area and placed in the river.

1.4 Design Support Activities

Several design support activities have been initiated and are in varying stages of progress. These activities are illustrated on Figure 1-4, which shows the many data sources feeding the RD.

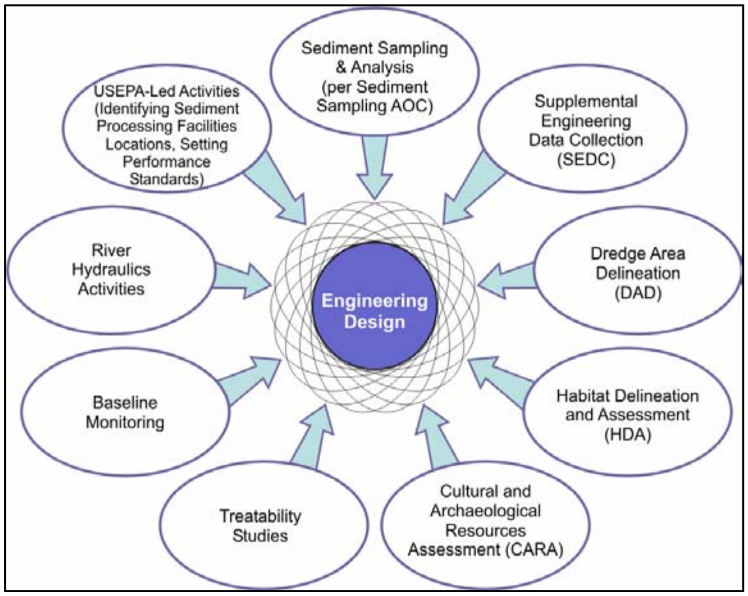

Figure 1-4 – Design Support Activities

These design support activities will provide the information necessary to develop the engineering design. For example, the Supplemental Engineering Data Collection (SEDC) activities will support the design in many ways, such as by: 1) identifying the presence and characteristics of structures/debris (i.e., boulders, man-made obstructions, and debris) present in areas targeted for removal; 2) evaluating the suitability of available backfill materials; and 3) generating additional data regarding engineering characteristics of sediments and underlying strata to support the RD (i.e., geotechnical properties of in-river sediments and underlying strata; dredgeability of sediments to be removed; and slope stability adjacent to dredge areas during and following dredging).

Thus, successful completion of the design support activities is necessary for the completion of the subsequent design submittals (i.e., Intermediate and Final Design). Further details of these activities are provided in the RD Work Plan (BBL, 2003a).

1.5 Preliminary Design Report Organization

This *Preliminary Design Report* is organized into the sections shown in Table 1-1, below.

Table 1-1 – Preliminary Design Report Organization

Section	Description
1 – Introduction	Provides a discussion of the project setting, remedial action (RA), and RD objectives for the project, as well as an overview of the organization of the *Preliminary Design Report*.
2 – Overview of the Remedial Design Process	Describes the RD process, including project constraints, design approach, design integration, optimization process, and RD schedule.
3 – Site Characteristics	Describes the different aspects of site characteristics related to the Preliminary Design. Includes discussion on upland, hydraulic and

Section	Description
	sediment characteristics, as well as a general discussion on dredge areas, habitats, cultural and archaeological factors, and climatological factors.
4 – General Design Considerations	Describes the general design considerations for developing the Preliminary Design.
5 – Dredging Design	Describes the preliminary components and analysis of the dredging project element.
6 – Resuspension Control	Describes the preliminary components and analysis of the resuspension control systems project element.
7 – Dredged Material Transport	Describes the preliminary components and analysis of the dredged material transport project element.
8 – Sediment and Water Processing	Describes the preliminary components and analysis of the sediment and water processing project element.
9 – Transportation for Disposal or Beneficial Use	Describes the methods to be used for the final transportation of processed material for disposal or beneficial use.
10 – Disposal	Describes the methods to be used for the disposal of processed material.
11 – Backfilling/Capping	Describes the methods for designing material to be used for backfilling/capping.
12 – Habitat Replacement and Reconstruction	Briefly describes the general approach to the habitat replacement and reconstruction program.
13 – Permit Equivalency Analysis	Identifies the federal, state, and local environmental laws and regulations that may be applicable to the project and explains how the design will meet the substantive requirements.
14 – Preliminary Construction Schedule, Contracting Approaches, and Construction Specifications	Addresses construction issues pertaining to work task scheduling presents options for contracting approaches and briefly discusses construction specifications.
15 – Value Engineering Scope	Provides a preliminary scope for the Value Engineering Study.
16 – References	Presents references that are cited in this *Preliminary Design Report*.
17 – Acronyms	Provides definitions of key acronyms that are used in this *Preliminary Design Report*.
Tables	Provides tables that are referenced in this *Preliminary Design Report*.
Figures	Provides figures that are referenced in this *Preliminary Design Report*.
Appendices	Provides appendices that are referenced in this *Preliminary Design Report*.

This *Preliminary Design Report*, submitted under the RD AOC (USEPA/GE, 2003), was developed based on existing data and information and is not able to reflect the yet unavailable results from the sampling work, treatability study data, or information on final siting and performance standards. Subsequent design reports will incorporate the results/data from these efforts, as further described in the RD Work Plan (BBL, 2003a).

2. Overview of the Remedial Design Process

This section presents an overview of the RD process, project constraints resulting from USEPA requirements and site characteristics (from logistical and physical constraints), design approach, design integration and optimization, and an overview of the RD schedule. Following execution of the RD AOC (USEPA/GE, 2003), several design support activities began simultaneously with the goal of collecting information needed for the RD as discussed in the RD Work Plan (BBL, 2003a). These activities included:

- Development of the *Supplemental Engineering Data Collection Work Plan* (SEDC Work Plan) (BBL, 2003b);
- Habitat delineation and assessment (HDA) activities (specified in the *Habitat Delineation and Assessment Work Plan* [HDA Work Plan] [BBL, 2003c]);
- Cultural and archaeological resources assessment (CARA) activities (specified in the *Cultural and Archaeological Resources Assessment Work Plan* [CARA Work Plan] [URS, 2003]);
- Development of the *Treatability Studies Work Plan* (TS Work Plan) (BBL, 2003d);
- Development of the *Baseline Monitoring Program – Quality Assurance Project Plan* (BMP-QAPP) (Quantitative Environmental Analysis, LLC [QEA], 2003); and
- Dredge area delineation (DAD) efforts.

Note that data collection has not begun for the SEDC, treatability studies, and baseline monitoring programs, since the work plans for those efforts have not yet been approved by the USEPA.

As shown on Figure 1-3 (provided in Section 1), the design sequence has three steps: Preliminary, Intermediate, and Final Designs. After the Preliminary Design stage, separate designs for Phase 1 and Phase 2 of the project will be undertaken on different schedules. The following paragraphs describe the type of information and analysis that will occur in each design step. As the design proceeds from Preliminary to Final, details will emerge that will culminate in Final Design specifications that can be used to contract for project implementation.

- ***Preliminary Design***: At this stage of design, critical information is still being developed. The goal of this phase is to determine realistic process options to retain for each major step in the remedy and to determine key process variables (KPVs) for the various project elements. Information on areas to be dredged, volumes to be removed, production rate requirements, water quality requirements, resuspension constraints, PCB residual requirements, noise and air pollution limitations, habitat replacement and reconstruction requirements, and cultural resources are currently being developed. As a result, quantitative evaluations of the process options are not possible at this stage of the design. The TS Work Plan (BBL, 2003d) proposes additional process-specific data collection and testing needs and was developed based on the Preliminary Design evaluation.

- ***Intermediate Design***: Separate Intermediate Designs will be developed for Phase 1 and Phase 2 of the project. As recognized in the RD Work Plan (BBL, 2003a), this phase of the design cannot be completed until the Phase 1 and Phase 2 dredge areas and volumes have been determined, treatability studies have been completed, and other necessary activities, such as USEPA selection of the processing facilities, as well as finalization of the performance standards by the USEPA, have been completed. This information will be used to quantitatively evaluate and select process options, size the selected unit processes, and optimize the overall processing train to manage uncertainty in performance while reducing costs. In addition, during Intermediate Design, an independent group of experienced professionals will be convened to perform a Value Engineering Study (see Section 15).

- ***Final Design***: Separate Final Designs will be developed for Phase 1 and Phase 2 of the project. The goal is to have detailed design specifications ready for contracting. As noted previously, changes in the Phase 2 Final Design may be necessary as a result of the evaluation and independent peer review of the Phase 1 dredging project. The Final Design will also incorporate data from the SEDC efforts and supplemental treatability studies (if any), habitat assessment activities, and CARA evaluations. Quantitative evaluation of the entire project (i.e., dredging to disposal processes) will also be undertaken to confirm that KPV requirements (e.g., production rates) are accounted for and the impact of uncertainty in these variables is properly managed.

2.1 Project Constraints

Efficient development of the RD is challenged by several important constraints on the project design. These constraints derive from: 1) the performance standards established by the USEPA; 2) other requirements or prohibitions set forth in the ROD (USEPA, 2002a) or to be established by the USEPA for the project; 3) existing logistical and physical conditions at the site; and 4) other considerations resulting from the uniqueness and complexity of the project. These constraints are identified below and discussed further in Section 4.

2.1.1 Engineering Performance Standards

The *Draft Engineering Performance Standards – Peer Review Copy* (Malcolm Pirnie and TAMS, 2003) was issued in October 2003. This document addresses the three main components of the Engineering Performance Standards – dredging-related resuspension, dredging residuals, and dredging productivity (discussed in sub-section 4.1). This document proposes both performance requirements and procedures for the dredging element of the project. It is currently undergoing peer review. The peer review panel is expected to evaluate whether the proposed Engineering Performance Standards are technically adequate, are properly documented, and satisfy quality requirements. A public meeting of the peer review panel will be held in late January 2004, and the USEPA expects to finalize the Engineering Performance Standards in early 2004, following receipt of the panel's recommendation.

The resulting final Engineering Performance Standards will establish key constraints on the design of the project. At this time, it is unknown whether the project will be able to achieve all three Engineering Performance Standards simultaneously – e.g., whether it will be able to meet the resuspension and residuals standards while also achieving the production rates specified in the productivity standard. In its comments to the USEPA and the Peer Review Panel GE seriously questioned the achievability given the lack of precedent demonstrating the achievement of all three standards. While the project will be designed to achieve all three standards, the project's ability to do so will be uncertain until it is tested in Phase 1. As stated in the RD Work Plan (BBL, 2003a), if, at any time during the design process, GE concludes that it would not be feasible for all or part of the dredging project to achieve the Engineering Performance Standards, Quality of Life Performance Standards, or other governmental requirements applicable to the project (as discussed below) – whether individually or in combination – GE will promptly notify the USEPA.

2.1.2 Quality of Life Performance Standards

The USEPA's Quality of Life Performance Standards have just been issued for Public Review and as such the details are not incorporated in this report. The Quality of Life Performance Standards were developed with the goal to minimize the potential for adverse impacts on the quality of life of the surrounding community from the project (i.e., components such as dredging, transport, resuspension, sediment and water processing, backfilling/capping, and habitat replacement and reconstruction). These performance standards address the following five areas:

- Air quality;
- Odor;
- Noise;
- Lighting; and
- Navigation.

Note that these Quality of Life Performance Standards are expected to impose further constraints on the design of the project.

2.1.3 Other USEPA Requirements and Limitations

Several other USEPA-imposed requirements are applicable to the project; the design must adhere to these additional requirements, which are set forth in the ROD (USEPA, 2002a) and elsewhere. These constraints include the following:

- The ROD's prohibition on using trucks to transport dredged material out of the Hudson River Valley for final disposal (using trucks for material designated for beneficial use may be considered);
- The ROD's requirement that the dredged material destined for disposal must be shipped to a disposal facility outside the Hudson River Valley;
- The chemical-specific, action-specific, and location-specific applicable or relevant and appropriate requirements (ARARs) specified in the ROD; and
- Any additional limitations on constituent releases that may be imposed by the USEPA as a result of the New York State (NYS) water quality "certification" (currently being developed by the NYSDEC) or otherwise.

2.1.4 Logistical and Physical Constraints

In addition to the constraints imposed by the USEPA requirements for this project, the project design will be constrained by a number of existing logistical and physical considerations. These include the following:

- Limitations on available infrastructure (e.g., rail, barge, roads) in the project area;
- Limitations on in-river transport, such as those deriving from low bridge heights, canal logistics and lock operations;
- The need to maintain recreational use of the Hudson River throughout the project;
- Limitations on rail capacity and uncertainties in rail service, which could significantly affect the transportation process and thus impact the preceding operations;
- River access, including special considerations for sediment removal and transport from the land-locked area of the Upper Hudson River;
- The limited dredging season due to weather conditions in eastern New York; and
- River-flow conditions, particularly the occurrence of high flows that would preclude safe working in the river.

2.1.5 Other Considerations Resulting from Scale of the Project

Finally, a number of other project constraints result from the uniqueness and complexity of this project. For example:

- An environmental dredging project of this scale has never been attempted. As such, the scale and complexity of the RD for this project is unprecedented. Other environmental dredging projects have been smaller in scale than this project − the experience from those projects will have to be carefully considered in the RD.
- Health and safety (both public and worker) and security pose unique challenges, given the size and duration of this project.
- Cost optimization will be an important consideration in the RD, given the magnitude of this project and the interrelationships among the project elements.
- Potential limitations on the availability of equipment or materials for a project of this scale.

2.2 Design Approach

This sub-section describes the approach undertaken in design and also provides a lexicon that will be used throughout design. The following operational definitions will be used throughout the design process.

- **Project:** The entire sequence of steps from sediment removal to disposal, including habitat replacement and reconstruction.
- **Project Elements:** The individual steps in the project such as dredging, transport for disposal, sediment and water processing, backfilling/capping, and habitat replacement and reconstruction.
- **Process Options:** These are the first-level technology options being considered for each project element (e.g., use of mechanical or hydraulic dredges, or both). Project constraints (e.g., not allowing trucking of dewatered material for disposal) may limit available process options.
- **Process Sub-Options:** These are second-level technology options under the process options (e.g., use of a clamshell bucket as the mechanical dredge process option).
- **Project Requirements:** These are the requirements that affect all or many of the project elements (e.g., production rate). Overall, the project must remove and dispose of a certain quantity of material in a given timeframe (e.g., under the current draft productivity standard, a minimum removal and disposal in Phase 2 of 480,000 cy per year with a target of 530,000 cy per year is required). On an individual project-element level (like dredging) this would translate into removing a certain volume of in-situ sediment within a specified time period (cy per year or tons per year). Similarly, it will be necessary for the processing facilities to treat the volume of water generated from the dredging activities. As a result, the entire project must be evaluated, modeled, and optimized to maximize the probability of achieving the project goals.
- **Process Requirements:** These are the specific requirements that the project elements must achieve. Process requirements are derived from the basis of design for each project element, along with the project constraints as described in sub-section 2.1. Examples of a process requirement include limiting PCB resuspension to comply with the USEPA's draft resuspension standard, or the need to process a given amount of material to achieve the USEPA's draft productivity standard. The process requirement may be a fixed value or a variable within specified limits.
- **KPVs:** KPVs are measurable variables (some are controllable) for each project element that affect the achievement of the process requirements. Examples include the impact of a dredge-operational variable (such as dredge-head speed) on resuspension; or the impact of percent (%) solids on the sizing of the water

treatment plant. Typically, these values are variable and may have significant uncertainty. An important goal of the design is to identify, understand, and attempt to manage the variability and uncertainty.

The project elements are depicted on Figure 2-1, below.

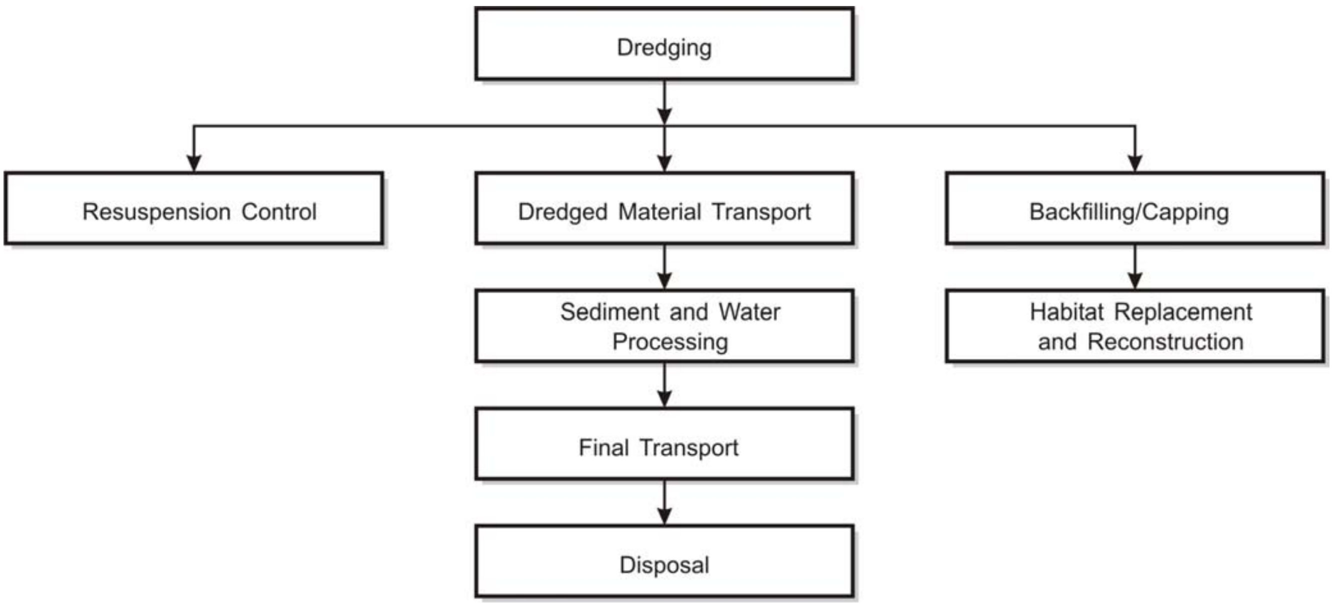

Figure 2-1 – Remedial Project Elements

While these project elements may be considered individual components, they are interrelated, meaning that the output from one element drives the input for another (and in some cases, for several other project elements). The interrelationship of each of the inputs and outputs for each project element is depicted on Figure 2-2, which shows the various project elements, their inputs and outputs, and the associated interrelationships. The output of one element will have a major impact on the design of processes that follow. Therefore, during the design process, a "project" design approach will not only be used to account for the individual process options, requirements, and KPV, but also to account for the input/output interrelationships. Each of the project elements typically has several process options. Figure 2-3 presents a process flow schematic that illustrates some of the various process options for relevant project elements. The process options are discussed in the design sections of this *Preliminary Design Report* (Sections 5 through 12). As the design proceeds, process options for each project element will be evaluated and different "project scenarios" (i.e., complete train of elements) will be evaluated against the project requirements. The aggregated process options will be evaluated together to optimize cost and manage uncertainty.

Each stage of the design approach will use the existing information on dredge areas, material characterization, and project constraints. Additional design approaches include:

1. Developing process options for each project element;
2. Specifying known project and process constraints;
3. Developing quantitative relationships for KPVs and accounting for uncertainty and variability in their relationships; and
4. Developing simulations using different process options and optimizing operations to achieve project requirements in a cost-effective manner.

During the Preliminary Design stage, existing site information that will assist in designing the project will be summarized. Since much of the design-support data is still being collected, and the project constraints are not fully developed, this *Preliminary Design Report* describes the process options currently being considered and provides information on the analysis of KPVs.

2.3 Design Integration and Optimization Process

Because the design process for the Hudson River project is composed of project elements that are interrelated, the entire design must follow an integrated "project" design approach if it is to result in a safe and efficient program. While each of the project elements will be designed in parallel, sufficient and frequent communication and exchange of information will be necessary among the various members of the design team to facilitate an integrated evaluation of the potential impacts of certain process options, process requirements and KPVs on other project elements.

The design integration and optimization process will be implemented using the following six steps:

1. Define design objectives;
2. Define relationship between design objectives and KPVs;
3. Determine the KPVs that have a significant impact on achieving a given design objective;
4. Determine the interrelationship between the KPVs;
5. Evaluate process options (or sub-options) based on the relevant KPVs; and

6. Optimize the project design by optimizing the KPV, subject to the constraints mentioned in sub-section 2.1.

The result of this process will be the development of "trade-off matrices" that will help the designer to evaluate the pros and cons of the particular process option (or sub-option). Data to help define such relationships will be collected from the applicable field programs (e.g., SSAP, SEDC, or treatability studies). However, some uncertainty in the relationship will remain, and attempts to understand its impact on project performance will be undertaken.

The overall objective of the optimization step is to identify those combinations of process options that will achieve the performance standards in the most schedule-sensitive and cost-effective manner. The general approach of the optimization process is to produce comparative cost estimates between various sets of design.

The results from the optimization will be used to identify the importance and understand the cost sensitivity of the KPVs at the project level, thereby helping to develop the most efficient process and subsequently, an optimized design for the project. This design optimization step will be completed in the Phase 1 and Phase 2 Intermediate and Final Design stages of the project. As such, further discussion on these topics will be covered in the *Phase 1* and *Phase 2 Intermediate* and *Final Design Reports*.

2.4 Remedial Design Schedule

The schedule for RD deliverables is outlined in Table 2-1. This schedule was originally set forth in Table 4 of the approved RD Work Plan (BBL, 2003a), but has been updated to reflect events that have occurred since completion of the RD Work Plan. Because of the scheduling uncertainties associated with several tasks that are out of GE's control (e.g., seasonal constraints, USEPA review periods, USEPA-led tasks, the need to fill data gaps), important deliverables and design activities are summarized in Table 2-1 relative to key milestones and other conditions. Note that the tasks that are being managed by the USEPA (e.g., establishment of performance standards, evaluation and identification of locations for land-based processing facilities) are not listed in Table 2-1, other than to indicate their relationship to other tasks in the table.

3. Site Characteristics

Data on various aspects of the site are integral to the design of each project element. Site characterization data were drawn from a number of sources to develop the Preliminary Design. Historical site information was obtained from the Hudson River Reassessment FS (USEPA, 2000), the database provided by Ecology & Environment (E&E, 2003), and other publicly available sources. The spring 2002 aerial mapping and results from the SSAP, CARA, and HDA efforts provided additional, more recent site information.

Specifically, this Preliminary Design was developed using the following information:

- Upland characteristics;
- Hydraulic characteristics;
- Sediment characteristics;
- Bathymetry;
- Debris;
- Habitats; and
- Cultural and archaeological features.

Figures 3-1 through 3-43 depict characteristic features along the Upper Hudson River that have been identified to date. Additional site characterization information will be generated by the ongoing design support activities, including the SEDC Program. The data on Figures 3-1 through 3-43, and the site characterization discussion herein, are preliminary (due to the limited data available at this stage of the project), and will be updated in the *Phase 1* and *Phase 2 Intermediate Design Reports*.

3.1 Upland Characteristics

Portions of the project may affect and/or require use of upland areas adjacent to the Hudson River. For example, in certain cases, river dredging may directly impinge on the river shoreline. In addition, land-based processing facilities will be constructed and operated adjacent to the river and rail and barge facilities and infrastructure will be constructed, operated, and maintained near the processing facilities. Local roads will be utilized for the transfer of labor, materials, and supplies to support the dredging project. Hence, a good knowledge of the relevant characteristics of the areas adjacent to the river is important to the RD. Information on shorelines, land-based transportation, and property ownership are discussed in the following sub-sections.

3.1.1 Shoreline Characteristics

The characteristics of the shoreline affect a number of project elements, including stability of the sediments and banks after dredging along the shoreline, required dockage and other waterfront access needs for the processing facilities, and specific criteria for habitat replacement and reconstruction. Physical characteristics of the shoreline, topography, and shoreline structures were considered during development of the Preliminary Design. Specific descriptions of the shoreline features are provided in the sub-sections below.

3.1.1.1 Shoreline Physical Characteristics

The type of shoreline adjacent to dredge areas may directly affect the implementation of the dredging program and must be considered during the design. For example, vegetative cover and overhanging trees will affect the ability to access the shoreline with the dredging equipment to complete the required removal. Likewise, the presence of rip-rap will be important for the dredging design (e.g., it may limit the use of hydraulic dredging equipment).

Two general shoreline types are located within the project area: maintained (i.e., engineered) and natural (i.e., unconsolidated shore, as defined by Cowardin et al., 1979). Maintained shorelines are areas where the shoreline has been stabilized with rip-rap, bulkhead piling, or concrete to reduce erosion. Natural shorelines are areas with well-developed vegetative communities, including a well-defined canopy, scrub/shrub layer, groundcover, and/or area of bedrock outcropping. Natural shorelines are not stabilized by engineered materials.

As part of the SEDC and HDA programs, additional information on shorelines will be collected and evaluated with the results from the DAD process. The results of these evaluations will be presented in greater detail in subsequent design reports.

3.1.1.2 Shoreline Topography

The topography of the shoreline will be considered in the design of the dredging program, as well as in the sediment processing and transportation aspects of the project design. As an example, in areas where the shoreline is steeply sloped, removing sediment during dredging along the toe of the slope may create slope instability. Furthermore, steep side-slope conditions may prevent adequate access to the shoreline during dredging activities.

Figures 3-1 through 3-43 show the available information on the shoreline topography at the site. The shoreline topography along the Upper Hudson River varies from relatively flat (floodplain areas) to steeply sloped (rock outcrops and bluffs). The HDA activities will provide additional information on shoreline topography, which will be used to update these figures during the Phase 1 and Phase 2 Intermediate Design stages.

3.1.1.3 Shoreline Structures

The presence of shoreline structures may inhibit the ability to access a specific area or may make it more difficult to complete dredging. A preliminary inventory of shoreline structures was conducted using aerial mapping. Figures 3-1 through 3-43 depict the results, which include locks, bridges, overhead and buried utility crossings, dams, rock cribs, and other major in-river structures. Information on locks, dams, and bridges is presented in sub-section 3.2.4. Note that additional data on shoreline structures will be collected as part of the SEDC Program, and the results presented in the subsequent design reports.

3.1.2 Land-Based Transportation Characteristics

An adequate road and rail system is required to support the construction of processing facilities, the transport of equipment and materials (e.g., backfill, supplies, labor resources) to the project area, and the transport of processed material leaving the project area. It is also possible, that the stability of roads adjacent to the Hudson River may be impacted by encroaching dredging operations. The following sub-sections provide an overview of the road and rail infrastructure along the Upper Hudson River and how, in general, this infrastructure may support or be impacted by the project.

3.1.2.1 Roadways

Roadways will be used to transport personnel, equipment, and materials to support the dredging operations and the processing facility. Roadways may also be used to transport dredged material to the processing facility under special circumstances (such as in the land-locked area) and processed material designated for beneficial use. The stability of roadbeds close to the shoreline may be affected by dredging activities.

The roads in the Upper Hudson River area are generally rural, two-lane, local access roadways. The only four-lane limited access highway is Interstate I-87 (Northway), which parallels the Upper Hudson River. Other roadways of importance to the project in River Section 1 include U.S. Highway 4, NYS Route 197/Reynolds Road, and County Highway 29/West River Road. Roadways of interest in River Sections 2 and 3 include U.S. Highway 4; NYS Routes 32, 29, 67, 146, 118, and 470; and County Highways 29, 46, 113, 120, and 121. As part of the SEDC Program, additional detailed information on relevant portions of these roadways will be collected (including vertical clearance/height, weight, and width restrictions) and evaluated in concert with the results of the DAD process. The results of these evaluations will be presented in greater detail in subsequent design reports.

3.1.2.2 Railroads

Railroads may be used to transport dewatered dredged material to the disposal site. Equipment and materials (to support the dredging operations and the processing facility) may also be transported via rail. In addition, railroads may be used to transport the backfill/cap material for habitat replacement and reconstruction purposes.

The railroad infrastructure in the Upper Hudson River area is a vestige of the period when the area was more industrial in character. Active rail lines owned and operated by CSX Transportation Inc. (CSXT), Norfolk Southern Railway (NS), Guilford Rail System (GRS), Batten Kill Railroad, Inc. (BKRR) and Canadian Pacific Railway (CPR) are in the vicinity of the project area. However the movement and transfer of processed material by railroad, in the volumes and time periods contemplated by the USEPA, will require that a significant amount of new rail infrastructure be constructed at the processing facility site(s). NS, CPR, and CSXT are Class I railroads and have the system-wide infrastructure and equipment that could be used to support the project, including (in the case of CSXT and CPR) providing a single-line haul to the final disposal destination. In general, CPR is the most dominant carrier in this area, with tracks and/or operating rights extending from the northern to southern boundaries of the project area. CSXT's ability to directly serve potential processing sites is confined to the southern end of the project area, but the railroad can participate in joint line movements with CPR and GRS at other locations. NS has certain rights that enable it to provide rail service to and from the Mechanicville, NY area. GRS is a large regional railroad that has the system infrastructure to support the project, but may not provide a continuous single line haul to a final disposal destination. The BKRR is a small, local, short line railroad that has limited rail infrastructure, but could participate in a joint haul with CPR, GRS or other railroads.

3.1.3 Property Ownership

Information on property ownership is critical to identifying and obtaining access and rights-of-way for various activities related to the project. Data from the FS (USEPA, 2000), E&E database (E&E, 2003), and tax map information will be reviewed to determine the ownership of properties located adjacent to potential dredge areas and processing facilities. Detailed information regarding property required for access routes, acquisition for use as staging areas for other purposes, or easements will be collected as part of the SEDC Program and presented in the *Phase 1* and *Phase 2 Intermediate* and *Final Design Reports*.

3.2 Hydraulic Characteristics

Hydraulic characteristics are necessary not only for defining the range of in-river characteristics that the project will need to account for, but also for obtaining a general understanding of river dynamics and features. This sub-section summarizes the hydraulic characteristics of the Upper Hudson River, including: river flow, bathymetry, navigation channel, locks, dams and bridges, and in-river characteristics. This sub-section also provides a brief overview of historical flow conditions (average flow conditions), the history of extreme flow events (i.e., storm or heavy rain events), and volumetric flow rate and river velocity.

3.2.1 River Flow

River flow (both river velocities and flow volume) will be used in the design of the dredging program, resuspension controls and contingency planning. It is important to understand the hydraulic characteristics of the river to produce an effective design for the in-river operations. For example, the successful deployment and use of the resuspension control systems are a function of the expected range of river flow conditions at a particular location. Also, dredges and support vessels will account for expected river flow conditions to define their operability parameters and limits of safe and efficient operation.

In River Section 1, the flow rate is measured at the United States Geological Survey (USGS) gauging station at Fort Edward, which has been operating since 1977. Prior to 1977, discharge data were obtained at two USGS gauges located upstream of River Section 1, at Hadley and Stewarts Bridge. Data from these two upstream stations were used to estimate flow rates at Fort Edward from 1930 to 1977. This made it possible to construct a 73-year record (1930 to 2002) of daily-average flow rates at Fort Edward.

A historic analysis of the Fort Edward flow record was conducted to provide a better understanding of seasonal variations in discharge. The monthly discharge statistics, for May through November, are presented in Table 3-1, below.

Table 3-1 – Seasonal Flow Rate Variation at Fort Edward (1930-2002)

Month	Average Flow (cfs)	Maximum Flow (cfs)	Frequency of Flow > 5,000 cfs (%)	Frequency of Flow > 10,000 cfs (%)
May	7,650	35,210	59	25
June	4,450	38,230	27	4
July	3,330	20,550	11	1
August	3,060	8,760	5	0
September	3,140	22,980	5	< 1
October	3,860	22,590	15	3
November	4,830	21,400	37	3

Note:
1. cfs = cubic ft per second

Since the USGS gauging stations at Stillwater and Waterford have not been operational for several years, flow rates in River Sections 2 and 3 were estimated using a drainage area proration method. This method uses the ratio between the drainage area at a downstream location and the drainage area at the USGS Fort Edward gauge. The drainage areas at Fort Edward, Stillwater, and Waterford (2,817, 3,773, and 4,611 square miles [mi^2], respectively) were used for this analysis. Thus, discharge at Fort Edward is multiplied by 1.34 and 1.64 to estimate flow at Stillwater and Waterford, respectively.

Diurnal variations in flow rate may occur due to water releases primarily from the Sacandaga Reservoir and, to a lesser extent, other hydroelectric facilities located upstream of River Section 1. These releases can cause discharge in the river to vary by 1,000 to 4,000 cfs during a single day. Increases or decreases in flow rate may occur over a period of 1 or 2 hours. Available information on scheduled releases from hydroelectric plants will be collected during the SEDC Program and will be used to evaluate expected flow conditions.

Current velocity data were collected along five transects in River Section 1 near Snook Kill during August 1997 (O'Brien & Gere, 1998). The flow rate at Fort Edward during this period was approximately 2,800 cfs. The measured velocities were variable and ranged from <0.1 to 1.5 ft per second (fps).

Water surface elevation (or stage height) varies with flow rate − stage height increases as discharge increases. Information on stage height will be related to water depth in order to evaluate potential access limitations during dredging and other in-water activities. Rating curves, which specify stage height as a function of flow rate, were developed using data collected at two locations in River Section 1: 1) USGS gauging station at Fort Edward; and 2) NYS Canal Corporation gauge at Crockers Reef (near entrance to Lock 6). The rating curves were used to estimate the stage height over a range of flow rates (Tables 3-2 and 3-3, below). Data collected at NYS Canal Corporation gauges were used to develop stage height rating curves in other sections of the river. Estimated stage heights over a range of flow rates at these locations are listed in Tables 3-2 and 3-3, below. The water surface elevation is referenced relative to mean sea level (MSL).

Table 3-2 – Stage Height in River Section 1 (referenced to MSL)

Flow Rate (cfs)	Stage Height at Fort Edward (ft)	Stage Height at Crockers Reef (ft)
2,000	120.7	119.8
5,000	121.9	120.7
10,000	123.2	121.6
15,000	124.1	122.3

Table 3-3 – Stage Height in River Sections 2 and 3 (referenced to MSL)

Flow Rate (cfs)	Stage Height at Northumberland Dam (ft)	Stage Height at Stillwater Dam (ft)	Stage Height at Mechanicville Dam (ft)	Stage Height at Lock 2 Dam (ft)	Stage Height at Lock 1 Dam (ft)
2,000	105.8	84.5	74.5	48.3	30.0
5,000	107.0	85.7	75.1	49.4	30.9
10,000	108.2	87.5	75.7	50.7	31.9
15,000	109.0	89.3	76.0	51.8	32.6

3.2.2 Bathymetry

Bathymetry is important for defining the removal volumes, in-river operation of vessels, and the installation and removal of resuspension control systems. For example, bathymetry (water depth), in combination with river flow, will define the viability of certain resuspension control systems, such as silt curtains. Also, a good knowledge of water depths is required for successful and safe operation of watercraft.

Bathymetry data were collected in River Section 1 during fall 2001, and available data are presented on Figures 3-1 though 3-5. Water depth in the central channel portion of the river ranges from 12 to 15 ft. Some near shore areas drop abruptly to maximum depths while other areas have more extensive near shore shallows (<6 ft). The data were collected along 361 bank-to-bank transects, with a spacing of about 100 ft between each transect. Approximately 277 data points were obtained along each transect, resulting in a typical spacing of 2 ft between soundings. The water depth data were used to calculate the elevation of the riverbed. These elevations were referenced to the elevation of a shore-based benchmark. This system accounted for variability in water elevation that occurred as a result of upstream hydroelectric and canal operations.

Bathymetry data were collected in River Sections 2 and 3 during 2003. In River Section 2, the data were collected along 255 bank-to-bank transects. In River Section 3, the data were collected along 1,117 bank-to-bank transects. Transects were spaced according to the protocols described in the *Sediment Sampling and Analysis Program - Field Sampling Plan* (SSAP-FSP) (QEA, 2002a). The area of River Section 3 between Locks 3 and 4 was not evaluated due to low water levels resulting from maintenance activities at the upper Mechanicville Dam (Lock 3). Bathymetry data for this area will be collected in 2004. Additionally, 120 bank-to-bank transects were collected in the Lock 6 land cut.

Additional bathymetric data on the river will be provided in the *Phase 1* and *Phase 2 Intermediate Design Reports*.

3.2.3 Navigation Channel

Navigation channel locations are important for in-river operation of both project and non-project vessels. From New York Harbor to Waterford (155 river miles), the navigation channel in the Hudson River is called the Hudson River Federal (Navigation) Channel (HRFC). The HRFC is maintained by the United States Army Corps of Engineers (USACE). From Waterford to Fort Edward (35 river miles), the navigation channel in the Hudson River is called the Champlain Canal and is part of the NYS Canal System. This 35-mile stretch of river is traversed via seven locks (Locks 1 through 7, in a south to north direction). The Champlain Canal is maintained by the NYS Canal Corporation, which is a subsidiary of the NYS Thruway Authority. The Champlain Canal continues north beyond Lock 7, via a land cut, to Lake Champlain. The navigation channel is approximately 200-ft wide, except in land cuts where it is about 75-ft wide.

3.2.4 Locks, Dams, and Bridges

Information on the location and characteristics of locks, dams, and bridges is important to understand navigability restrictions along the river and identify any restrictions on dredging and transport operations. Lock locations are presented on Figures 3-1 through 3-43, and a summary of the lock locations is presented in Table 3-4, below.

Table 3-4 – Locks in River Sections 1, 2, and 3

Lock	Approximate RM
7	193.7
6	186
5	182
4	168
3	165
2	163
1	159

Thompson Island Dam is a low-head dam at RM 188.5. The dam is at the upstream end of Thompson Island and is composed of two sections: 1) the western section, which is approximately 290 ft long; and 2) the eastern section, which is 500 ft long and approximately 4 ft high. Seven dams are located downstream of Thompson Island Dam. Dam locations are shown on Figures 3-1 through 3-43, and a summary of dam locations and dimensions is presented in Table 3-5, below.

Table 3-5 – Dams in River Sections 1, 2, and 3

Dam	RM	Crest Elevation (ft, MSL)	Length (ft)	Height (ft)
Thompson Island	188.5	119.3	787	4.0
Fort Miller	186.0	114.3	875	11.4
Northumberland	183.2	102.9	870	11.9
Stillwater	168.0	83.6	870	8.3
Upper Mechanicville	165.8	69.1	690	20.9
Lower Mechanicville	163.4	47.1	660	14.1
Waterford	159.5	28.6	610	12.3
Troy	153.9	16.3	1,200	14.0

Fourteen bridges span the Upper Hudson River. The locations of these bridges are presented on Figures 3-1 through 3-43, and listed in Table 3-6, below. The published clearance of the bridges will be reconfirmed during performance of SEDC activities.

Table 3-6 – Bridges in River Sections 1, 2, and 3

Bridge	Approximate RM	Published Clearance	
		Horizontal (ft)	Vertical (ft)
Rt. 197 W	194.3	100	*
Rt. 197 E	194.3	50	26
D&H RR W	194.2	100	*
D&H RR E	194.2	500	19
US Rt. 4	183	186	15
Dix (CT Rt. 42)	182	45	16
Ferry St. (NY RT. 29) W	181	80	15
Ferry St. (NY RT. 29) E	181	220	20
NY Rt. 915C	168	100	28
Eagle Bridge (B&M RR)	166	110	21
Hemstreet Park (NY RT. 67)	165	200	24
Lock C-2	163	45	23
Waterford (US Rt. 4)	156	175	22
112th Street (NY RT. 470)	155	160	20

Note:
* = Vertical clearance currently unidentified.

3.2.5 In-River Characteristics

A good knowledge of the in-river characteristics is important to understanding navigability restrictions along the river and identifying any restrictions on dredging and transport operations. For example, the dredging design will need to consider the presence of underwater debris and utilities. Inadequate or inaccurate delineation of such features could considerably impede the dredging operation and possibly compromise safety.

In-river characteristics of interest include the following:

- **Debris and abandoned structures:** Debris and abandoned structures assessed in the river include typical river debris (e.g., boulders, logs, shopping carts) as well as timber cribs filled with rocks, which were used during logging to assist the loggers during sorting of the logs. These structures are located throughout the river, primarily in River Sections 2 and 3.

- **Community use locations:** Community use locations include marinas and public use access points along the river. The Champlain Canal is heavily used for recreational boating. Several public marinas, along with secondary public access points, are located within the three river sections.
- **Wastewater and stormwater outfalls and sewers:** Numerous industrial and municipal wastewater and stormwater outfalls and sewers are located along the length of the Upper Hudson River.
- **Underwater utility crossings:** Submerged cables run below the river at several locations. Examples include RM 189 in River Section 1 and RM 182 in River Section 2.
- **Public drinking water intakes:** Two public drinking water intakes are located in River Section 3. The Town of Waterford water intake is at RM 157, and the Town of Halfmoon intake is at RM 159.
- **Other water intakes:** Other water intakes include industrial, agricultural, and other miscellaneous use intakes.

Additional details regarding the above-mentioned in-river characteristics will be collected during the SEDC Program, and presented as part of the *Phase 1* and *Phase 2 Intermediate Design Reports* and *Final Design Reports* (if information is available).

3.3 Dredge Areas

The dredge areas define the precise locations of sediment removal and affect a number of project elements, including dredging, resuspension control, sediment and water processing, transportation, backfilling/capping, and habitat replacement and reconstruction. The overall dredge volume from the ROD (approximately 2.65 million cy) (USEPA, 2002a) has been used for the Preliminary Design, since the DAD is being completed in parallel with the Preliminary Design. This estimate was used to conceptualize the overall approach for dredging presented in this *Preliminary Design Report* and to make a preliminary assessment of dredged material transport and sediment processing options. A more detailed evaluation, which will be presented in the *Phase 1* and *Phase 2 Intermediate Design Reports,* will incorporate the results of the DAD and, to the extent available, the SEDC Program.

3.4 Sediment Characteristics

The characteristics of the sediment (chemical, physical, and sub-bottom characteristics) within the likely dredge areas must be understood to produce an effective design since sediment characteristics affect all aspects of the design. This sub-section describes the sediment characteristics from a chemical and physical perspective.

3.4.1 Sediment PCB Characteristics

Sediment PCB characteristics (mass and concentration) will be used to initially define the dredge prisms, and also affect the design of sediment and water processing systems. Dredge areas based upon PCB concentration will be presented in the DAD Reports.

3.4.2 Sediment Physical Characteristics

Sediment physical characteristics (e.g., grain size, water content, and sediment strength) are important for defining the dredgeability of the sediments and efficiently designing the material processing and transport options. Several activities have been completed to determine sediment characteristics pursuant to the SSAP, including probing, geotechnical analysis of sediment samples, and a side-scan sonar survey. In 2002, Ocean Surveys, Inc. (OSI) completed side-scan sonar mapping in areas of River Sections 1 and 3 where safe navigation was possible. In 2003, side-scan sonar mapping of River Section 2 was completed. Based on the results of the side-scan sonar survey, the surface sediments were classified into five separate types, as summarized in Table 3-7, below.

Table 3-7 – River Bottom Classifications

Type	Characteristics/Description
Type 1	*Smooth, generally featureless bottom.* Ground truth data suggest riverbed is principally composed of *soft aqueous silty* sediments. Probes conducted in these areas often “felt” little or no resistance for at least the first foot of penetration into the bottom.
Type 2	*Smooth to mottled bottom*. Sand waves and scour-type features often observed within these areas. Ground truth data suggest riverbed is principally composed of *semi-compact to compact sand deposits*. Probes conducted in these areas generally “felt” resistance but penetrated the bottom. Gravel and isolated cobbles may be present within this bottom type.
Type 3	*Irregular bottom.* Ground truth data suggest riverbed is principally composed of *compact gravel and cobble deposits intermixed with sand.* Compact sediments typically prevented penetration of the probe into the bottom. Size and abundance of cobble deposits vary within this bottom type.
Type 4	*Smooth to irregular bottom*. Sediment types vary frequently within these areas over short horizontal distances. Differentiation of a single bottom type (encompassing a

Type	Characteristics/Description
	minimum area of approximately 50,000 ft²) could not be made. Probes conducted in these areas encountered *a varying assemblage of sediments typically associated with the Type I, II, and III areas.*
Type 5	*Extremely irregular bottom.* Ground truth data suggests *bedrock, hardpan, cobbles, boulders, and/or debris* are present within these areas, often overlain by a variable thickness of unconsolidated sediments.

Note:

1. ft^2 = square feet

Since delineation of the dredge areas has not been completed, a detailed analysis of the sediment characteristics of the removal areas has not been completed. Additional data will be collected during the SEDC Program, and an updated analysis of the sediment characteristics will be presented in the *Phase 1* and *Phase 2 Intermediate Design Reports* (if information is available) and *Final Design Reports*.

3.4.3 Sub-Bottom Characteristics

Sub-bottom characteristics (e.g., sediment type and sediment strength) are important for defining the dredgeability of the sediments (i.e., over-dredging) and efficiently designing the resuspension control systems (e.g., embedment depths for sheetpiles).

Several activities were conducted during the SSAP to characterize sub-bottom conditions and materials (i.e., sediment characteristics for the materials beneath, and adjacent to, the sediment removal layer) for the purposes of identifying bedrock or hardpan locations. These activities included probing, sampling, and completing a side-scan sonar survey. In addition, sub-bottom profiling tests were completed in three test plots in the fall of 2003. These data will be evaluated during the Phase 1 and Phase 2 Intermediate Design stages to determine the effectiveness of these tests in delineating sub-bottom conditions.

To further evaluate the characteristics of the material beneath and adjacent to the sediment removal layer (including bedrock conditions), geotechnical sampling and testing will be conducted as part of the SEDC Program. An analysis of the sub-bottom characteristics will be incorporated in subsequent design reports following completion and USEPA approval of the DAD Report(s).

3.5 Habitats

Implementation of the USEPA-selected remedy will result in changes in river hydrology, bathymetry, and geomorphology. As described in the HDA Work Plan (BBL, 2003c), the primary goal of the habitat replacement and reconstruction program is to replace the functions of Upper Hudson River habitats, through the use of both active and passive replacement/reconstruction techniques to within the range of functions found in similar physical settings in the Upper Hudson River.

An HDA Program is being conducted to document existing habitat conditions in and along the shoreline of the Upper Hudson River at areas that could be impacted by the USEPA-selected remedy. The range of functions found in the Upper Hudson River will be assessed primarily through measurement of associated structural parameters. Thus, the first step in the HDA Program is to establish the range of such structural parameters in the Upper Hudson River habitats prior to dredging. This is being done by measuring these parameters in areas that will be directly impacted by dredging and those that will not.

The HDA Program involves two activities (habitat delineation and habitat assessment) for each of the four primary habitat types:

- Unconsolidated river bottom (i.e., unvegetated river bottom);
- Aquatic beds (i.e., vegetated river bottom);
- Shoreline; and
- Wetlands.

The delineation involves review of existing data (e.g., NYSDEC wetland maps) and analysis of data collected specifically for the Hudson River project (e.g., aerial photography, side-scan sonar, and sediment data from the SSAP). This activity was completed in 2003 and will be reported in the *Habitat Delineation Report* for candidate Phase 1 areas, to be submitted in 2004.

Following completion of the habitat delineation, habitat assessments are to be conducted in representative areas for each type of habitat. The habitat assessments will rely mainly on field investigations and focus primarily on direct measurements of the physical structure of the habitats (see Table 3-8, below). These data will be used to develop habitat-specific design criteria for the habitat replacement and reconstruction program and recovery criteria for use in the adaptive management program. Habitat assessments for the candidate Phase 1 areas were completed in 2003. For the dredge areas covered by the Year 2 DAD Report, the habitat assessments will be conducted following USEPA approval of that DAD Report, in accordance with the schedule set forth in Table 2-1.

Table 3-8 – Delineation and Assessment Activities for Each Main Habitat Type

Habitat Type	Delineation	Assessment (data collected)
Unconsolidated River Bottom	Delineate unvegetated river bottom using side-scan sonar and sediment sampling data from SSAP	Inorganic substrate composition Organic substrate composition Epifaunal substrate/available cover Embeddedness Pool substrate characteristics
Aquatic Beds	Delineate submerged aquatic vegetation (SAV) beds from vertical aerial photography, as well as side-scan sonar and substrate characterization data from SSAP	Shoot density Percent cover Aboveground biomass Plant species composition Sediment nutrient availability Light attenuation Current velocity
Shoreline	Identify maintained and natural shoreline habitats from oblique aerial photography	Inorganic substrate composition Organic substrate composition Bank stability Bank vegetation components
Wetlands	Delineate fringing wetlands from vertical and oblique aerial photographs	Parcel size Interior core area Habitat connections Soil integrity Surface water connections Elevation Soil clay content Redoximorphic features "O" and "A" horizon cover Plant species composition Stem density Aboveground biomass

The design process for habitat replacement and reconstruction is discussed in Section 12.

3.6 Cultural and Archaeological Features

Cultural resources such as archaeological and historic sites and structures may be situated within and immediately adjacent to the river in locations that could be affected by dredging, sediment or backfill material transport, sediment processing operations, and rail infrastructure improvements. A CARA Work Plan (URS, 2003) was developed and is being implemented to identify resources and provide for their protection.

Information provided in the USEPA's Stage 1A Survey was used as the starting point in the assessment. The CARA Work Plan then expanded upon the Stage 1A Survey with additional historical information gained from further background research and consultations with knowledgeable individuals and institutions, field data collected as part of the SSAP, and recent aerial photography from the USEPA (as part of base-mapping work). The information is being used to develop archaeological sensitivity maps of the Upper Hudson River showing areas of "no," "low," and "high" potential to contain archaeological sites within the project's Area of Potential Effect (APE).

The sensitivity information will then be overlain by maps identifying the areas and depths to be dredged, as identified in the DAD Reports, to assess the potential for the remedy to affect areas of "high" potential to contain archaeological sites. In the event that such areas of "high" potential are located within areas and depths to be dredged, further evaluations will be made as to whether an archaeological site is, in fact, present; whether the dredging could have an adverse impact on the archaeological site; whether dredging can be avoided in any such area(s) (consistent with the overall goal of the dredging program); and whether additional investigations are necessary to obtain the requisite information. A similar evaluation will be made for the immediately adjacent shorelines that could be rendered unstable by the dredging, once those shoreline areas have been identified through the RD process.

3.7 Climatological Factors

Climatological factors such as precipitation and freezing could affect the project implementation by restricting the work schedule or even necessitating temporary shut-down of operations or early seasonal closures of operations. For example, the NYS Canal Corporation has indicated that lock closure does occur during certain high flow events. As such, the closure of the locks could necessitate temporary shut-down of operations. It is therefore important to gain a good understanding of these factors.

Meteorological data are collected at several stations in the area. The Glens Falls and Albany County Airports are weather stations of interest for River Sections 1, 2, and 3. Additional data on historical weather conditions will be collected during the SEDC Program and will be used to relate precipitation events to river-flow conditions. Precipitation data at the Glens Falls Airport are available from 1948 through 2002. These data are summarized in Table 3-9 (below) for the months from May through November.

Table 3-9 – Precipitation Measured at Glens Falls Airport (1948-2002)

Month	Average Monthly Precipitation (inches)	Maximum Daily Precipitation (inches)
May	3.32	2.30
June	3.21	3.44
July	3.26	2.84
August	3.38	3.65
September	3.06	3.55
October	2.81	3.57
November	3.10	2.08

Historical temperature measurements at the Glens Falls Airport are presented in Table 3-10, below. The period of record for these data is 1948 through 2002. Both the temperature range and the potential impacts of freezing temperatures were evaluated, particularly the impacts on productivity due to health and safety, and access concerns (due to ice accumulation and/or lock closure). For the months from May to November, cumulative freezing-degree days (i.e., days where the mean average temperature was 32° F or below) were determined for the period of record and are presented in Table 3-11, below.

Table 3-10 – Temperature (°F) Measured at Glens Falls Airport (1948-2002)

Month	Minimum Temperature	Average Minimum Temperature	Maximum Temperature	Average Maximum Temperature
May	22	44	93	68
June	32	54	97	77
July	40	58	100	81
August	31	56	98	79
September	25	48	97	70
October	15	37	87	59
November	-1	29	78	46

Note:
1. °F = degrees Fahrenheit

Table 3-11 - Freezing-Degree Days at Glens Falls Airport (1948-2002)

Month	Average Number of Freezing-Degree Days	Maximum Number of Freezing-Degree Days
May	0	0
June	0	0
July	0	0
August	0	0
September	0	0
October	2	4
November	5	22

Wind data are available at the Albany County Airport from 1984 through 2002. These data were analyzed on a monthly basis for the period from May through November. Wind roses were constructed for each month, and these diagrams are presented on Figures 3-44 through 3-51.

4. General Design Considerations

The primary challenge of the RD is to design the project to efficiently remove, process, and dispose of the required volume of sediments (estimated in the ROD at 2.65 million cy) from the Upper Hudson River in six dredging seasons/years, subject to numerous project requirements and other constraints identified in sub-section 2.1. This section provides a further discussion of several of those project constraints and related design considerations. Specifically, this section discusses the following important design considerations:

- Current draft of USEPA's Engineering Performance Standards;
- Current draft of USEPA's Quality of Life Performance Standards;
- Other limitations on releases of constituents;
- Equipment and material selection;
- Transportation issues;
- River access;
- Construction limitations; and
- State of the practice for environmental dredging (i.e., experience gained from past remedial dredging projects).

At this early stage of design development, it is impossible to predict whether the project can meet all the project constraints. The ability to achieve all of the project goals given the multitude of constraints will only be known after completion and review of Phase 1 dredging. However, as noted above and stated in the RD Work Plan (BBL, 2003a), if GE concludes at any time during design that it is not feasible to meet the established performance standards (individually or collectively) or other governmental requirements applicable to the project, GE will promptly inform the USEPA of that conclusion. However, lack of notification does not mean the project will definitively meet the standards. As noted above, this determination can only be made after Phase 1 of the dredging project is completed and reviewed.

Each of the general design considerations is discussed below.

4.1 Engineering Performance Standards

The USEPA has developed draft Engineering Performance Standards to address dredging-related resuspension, dredging residuals, and dredging productivity (Malcolm Pirnie and TAMS, 2003). The draft Engineering

Performance Standards will be finalized following a peer review, and the final standards will be used in the Phase 1 and Phase 2 Intermediate Designs. The final standards may be revised by the USEPA for Phase 2 after review of the Phase 1 data. Monitoring to assess achievement of the Engineering Performance Standards will be documented in separate monitoring plans to be developed during design. A summary of the standards, based on the USEPA's current draft of the Engineering Performance Standards (i.e., October 2003 Peer Review Copy), is presented below. If the final standards differ from the current draft, the basis of design will need to be revised accordingly.

4.1.1 Dredging Resuspension

The draft Engineering Performance Standard for resuspension is designed to limit the concentration of PCBs in the river due to dredging operations so as to protect the water supply intakes downstream of the dredging operations, and to attain the benefits of the remedy as described in the ROD (USEPA, 2002a), including limiting export of PCBs to the Lower Hudson River. The associated water quality monitoring program will verify that the objectives of the resuspension standard have been met during dredging. Monitoring will be performed regularly at "near-field" stations (located within a few hundred meters [m] of the dredging operation) for total suspended solids (TSS) concentrations and "far-field" stations (to be established at fixed locations in the Upper and Lower Hudson River, primarily dams and bridges) for both PCB and TSS concentrations. The analytical results obtained from the water quality monitoring will be compared to the resuspension standard and the other action levels. Actions will be taken, if necessary, to expand the monitoring program, notify public water suppliers, implement operational or engineering improvements, and temporarily halt the dredging.

Surface water monitoring data collected from various locations will be compared to three action levels, designated "Evaluation Level," "Concern Level," and "Control Level." The draft resuspension standard and action levels are summarized in Table 4-1, below.

Table 4-1 – Summary of the USEPA's Draft Resuspension Standard and Action Levels

Action Level	Parameter	Required Action (if exceeded)
Evaluation Level	• 300 g/day Total PCB load or 100 g/day Tri+ PCB load as a 7-day running average (far-field) • 100 mg/L 6-hour running average net suspended solids increase, or average net increase in the daily dredging period if the dredging period is less than 6 hours (near-field, 300 m, River Sections 1 and 3) • 60 mg/L 6-hour running average net suspended solids increase, or	Monitoring Contingencies Engineering Evaluations (recommended) Engineering Solutions (recommended)

Action Level	Parameter	Required Action (if exceeded)
	average net increase in the daily dredging period if the dredging period is less than 6 hours (near-field, 300 m, River Section 2) • 700 mg/L net suspended solids average 3-hour continuous (near field, 100 m and channel-side) • 12 mg/L 6-hour running average net suspended solids increase, or average net increase in the daily dredging period if the dredging period is less than 6 hours (far-field)	
Concern Level	• 350 ng/L Total PCBs as a 7-day running average (far-field) • 600 g/day Total PCB load or 200 g/day Tri+ PCB load as a 7-day running average (far-field) • 100 mg/L net suspended solids daily average for the dredging period (greater than 6 hours) or 24 hours (near-field, 300 m, River Sections 1 and 3) • 60 mg/L net suspended solids daily average for the dredging period (greater than 6 hours) or 24 hours (near-field, 300 m, River Section 2) • 24 mg/L net suspended solids daily average for the dredging period (greater than 6 hours) or 24 hours (far-field)	Monitoring Contingencies Engineering Evaluations Engineering Solutions (recommended)
Control Level	• 350 ng/L Total PCBs as a 4-week running average (far-field) • 65 kg/year Total PCB or 22 kg/year Tri+ PCB load during the dredging season (far-field) • 600 g/day Total PCB load or 200 g/day Tri+ PCB load as a 4-week running average (far-field)	Monitoring Contingencies Engineering Evaluations Engineering Solutions
Resuspension Standard	• 500 ng/L Total PCBs (confirmed far-field occurrence)	Temporarily Halt Dredging Monitoring Contingencies Engineering Evaluations Engineering Solutions

Notes:
1. Acronyms:
   g/day = grams per day
   kg/year = kilograms per year
   mg/L = milligrams per liter
   ng/L = nanograms per liter
2. Reference: Malcolm Pirnie and TAMS, 2003.

4.1.2 Dredging Residuals

The draft Engineering Performance Standard for dredging residuals is structured to measure and manage small amounts of PCBs in sediments that may remain on the river bottom after dredging. The draft residuals standard requires the collection of surface sediment samples following dredging to verify that the USEPA-prescribed residuals standard has been achieved. This standard specifies that each certification unit (CU) (i.e., approximately 5-acre discrete dredge areas to be individually dredged) be sampled for compliance after it is dredged so that further appropriate actions can be taken. In each CU, sediment samples representing the 0- to 6-inch depth interval of the post-dredging surface are to be obtained from 40 grid nodes and analyzed for Tri+ PCBs. The analytical results from those samples will be compared to the action levels in the draft residuals standard and, based on the results, the required actions will be taken. The action levels and associated required actions are summarized in Table 4-2, below.

Table 4-2 – Summary of the USEPA's Draft Residuals Standard

Case	CU Mean (mg/kg Tri+ PCBs)	No. of Sample Results where 27 > result ≥15 mg/kg Tri+ PCBs	No. of Sample Results ≥ 27 mg/kg Tri+ PCBs	No. of Re-Dredging Attempts Conducted	Required Action (when all conditions are met) [2]
A	$x_i \leq 1$	≤ 1	0	N/A	Backfill CU (where appropriate); no testing of backfill required.
B	N/A	≥ 2	N/A	< 2	Re-dredge sampling node(s) and re-sample.
C	N/A	N/A	1 or more	< 2	Re-dredge sampling node(s) and re-sample.
D	$1 < x_i \leq 3$	≤ 1	0	N/A	Evaluate 20-acre average concentration. If 20-acre average concentration ≤ 1 mg/kg Tri+ PCBs, place and sample backfill. If 20-acre average concentration > 1 mg/kg, follow actions for Case E below.
E	$3 < x_i \leq 6$	≤ 1	0	< 2	Construct subaqueous cap immediately OR re-dredge.
F	$x_i > 6$	N/A	N/A	0	Collect additional sediment samples to re-characterize vertical extent of contamination and re-dredge. If CU median > 6 mg/kg, entire CU must be sampled for vertical extent. If CU median ≤ 6 mg/kg, additional sampling required only in portions of CU contributing to elevated mean concentration.
G	$x_i > 6$	N/A	N/A	1	Re-dredge.
H	$x_i > 1$ (and 20-acre average >1)	≥ 2	≥ 1	2	Construct subaqueous cap (if any of these mean/sample result conditions are true) and two re-dredging attempts have been conducted OR choose to continue to re-dredge.

Notes:
1. Information is for each CU (size of approximately 5 acres) with 40 samples in each CU.
2. Except for Case H, where any of the listed conditions will require cap construction.
3. N/A = not applicable
4. mg/kg = milligrams per kilogram
5. Reference: Malcolm Pirnie and TAMS, 2003.

The draft residuals standard requires the review of the Tri+ PCB concentrations in the 40 individual sediment samples within each 5-acre CU; the mean Tri+ PCB concentration of the CU; the median Tri+ PCB concentration of the CU; and the average of the mean Tri+ PCB concentrations of a 20-acre joint evaluation area (CU under review and the closest three units within a 2-mile stretch of river). The various responses required for Phase 1 of the dredging project include backfill and demobilize, jointly evaluate a 20-acre area, re-dredge or construct a subaqueous cap, and conduct required re-dredging. The USEPA may adjust the draft residuals standard for Phase 2 based on its analysis of the post-dredging sediment data collected during Phase 1.

4.1.3 Dredging Productivity

The draft Engineering Performance Standard for productivity establishes minimum cumulative volumes of sediment to be dredged and processed in each dredging season, as provided in Table 4-3, below. The minimum cumulative volume of sediment to be removed, processed, and shipped off site by the end of each calendar year is the quantity shown in the "Minimum Cumulative Volume" column. The targeted total dredging volumes for the project are shown in the "Target Cumulative Volume" column. These volumes translate to a minimum volume of 240,000 cy in Phase 1 (with a target of 265,000 cy) and a minimum volume of 480,000 cy per year in Phase 2 (with a target of 530,000 cy per year in the first 4 years of Phase 2 and 265,000 cy in the last year).

Table 4-3 — Summary of the USEPA's Draft Productivity Standard

Dredging Season [1]	Minimum Cumulative Volume (cy)	Target Cumulative Volume (cy)
Phase 1	Approx. 240,000	265,000
Phase 2 (Year 1)	720,000	795,000
Phase 2 (Year 2)	1,200,000	1,325,000
Phase 2 (Year 3)	1,680,000	1,855,000
Phase 2 (Year 4)	2,160,000	2,385,000
Phase 2 (Year 5)	2,650,000 [2]	2,650,000 [2]

Notes:

1. The overall completion schedule, if appropriate, should be adjusted to be consistent with the total volume of sediment to be dredged as determined by the USEPA during RD (for example, based on the findings of the design support sediment characterization program).
2. Represents total estimated in-situ volume to be removed as per the ROD (USEPA, 2002a), exclusive of any amounts generated by re-dredging to meet the residuals standard.
3. Reference: Malcolm Pirnie and TAMS, 2003.

The draft productivity standard requires that monthly and annual progress reports be submitted to the USEPA. These reports will summarize daily records of the dredging locations, approximate production and number of operating hours for each dredge, estimates of in-situ sediment volumes removed, weight of dewatered sediments, and estimated mass of PCBs shipped off site. From these reports, productivity rates will be assessed and compared to the designated action levels.

The draft productivity standard's action levels and responses are summarized in Table 4-4, below.

Table 4-4 – Action Levels and Required Responses for the USEPA's Draft Productivity Standard

Action Level	Description	Required Action (if exceeded)
Concern Level	Monthly production rate falls 10% below scheduled rate.	Notify the USEPA and take immediate steps to erase shortfall in production over next 2 months.
Control Level	Production falls below scheduled production by 10% or more for 2 or more consecutive months.	Submit an action plan explaining the reasons for the production shortfall and describing the engineering and management actions taken or underway to increase production and erase shortfall by end of the dredging season.
Standard	Annual cumulative volume fails to meet required production requirements.	Action to be determined by the USEPA.

Note:
1. Reference: Malcolm Pirnie and TAMS, 2003.

4.2 Quality of Life Performance Standards

The USEPA has just recently released the draft Quality of Life Performance Standards for public review. When finalized, these standards will be considered in developing the project design. These standards address potential impacts to certain aspects of the community quality of life from the different project elements (i.e., dredging, dredged material transport, resuspension control, sediment and water processing, final transportation, disposal, and habitat replacement and reconstruction). Specifically, the Quality of Life Performance Standards address air quality, odor, noise, lighting, and navigation. The final Quality of Life Performance Standards could have a significant impact on the RD by imposing additional restrictions beyond the Engineering Performance Standards and other project constraints that could prevent the project goals from being met. The USEPA may revise these standards for Phase 2 based on the data from Phase 1 activities.

4.3 Other Limitations on Releases of Constituents

In addition to the USEPA-established performance standards, the project may be subject to other limitations (that are currently unknown) on discharges or other releases from project-related operations. These limitations could include requirements stemming from the NYS water quality certification process applicable to such discharges or releases, or other USEPA requirements. The USEPA may impose additional limitations on constituent discharges during the RA to address issues raised by the NYSDEC in the water quality certification process (note that the timeline for this process in currently unknown).

4.4 Availability of Equipment and Material

The proper selection of equipment and materials is a critical design decision that directly leads to a cost-effective and efficient RA implementation. Equipment and materials will be selected based on technical needs, requirements, and availability, with preliminary selection occurring during the Phase 1 and Phase 2 Intermediate Design stages. Specifically, construction equipment and materials will be conceptually selected, availability of these materials will be determined, and performance criteria will be established for the types of equipment expected to be used for this project. The availability of equipment and materials can pose a significant challenge to timely implementation of this project. Two primary components of the equipment and material selection process include an assessment of: a) contractor-supplied equipment; and b) materials and supplies. These components are discussed in the following sub-sections.

4.4.1 Contractor-Supplied Equipment

As part of the Phase 1 and Phase 2 Intermediate Design stages, contractor-supplied equipment for the RA elements (e.g., dredges and support barges) will be identified, and their availability and logistical considerations will be assessed.

4.4.2 Materials and Supplies

Some preliminary work has been conducted to assess the availability of materials and supplies that may either be unique or needed in large quantities for this project. These materials and supplies include, but are not limited to, backfill/cap material (e.g., sand, gravel); rail, barge, and/or truck equipment capable of transporting projected sediment and backfill/cap material volumes; and in-river containment systems (e.g., silt curtains, filter fabrics, steel sheeting). These items and their availability are addressed in their respective sections of this *Preliminary Design Report*.

The *Phase 1* and *Phase 2 Intermediate Design Reports* will provide preliminary specifications for the materials and supplies and their respective quantities required during the RA.

4.5 Transportation Issues

Of critical importance in designing any project that involves transporting millions of tons of material is developing a transportation plan to ensure that the material is moved efficiently, safely, and in a cost-effective manner. Such a plan must include the means by which the equipment moving the materials (e.g., trains or barges) will be "cycled" back and forth from the origin(s) to destination(s) so that all of the materials can be picked up and delivered to their final destination in a timely manner that does not delay the production end of the project. For the Hudson River project, the movement of bulk materials (e.g., dredged material, backfill/cap material) over land and water can be accomplished by rail, barge, and truck, individually or in combination. As stated above, however, the USEPA has eliminated trucks as a transportation mode for this project (except for beneficial use materials).

Key considerations in formulating the transportation plan include defining: 1) the type and volume of the material to be transported; 2) the distance that the material must travel and potential routes of movement; 3) available infrastructure and transportation providers; 4) the existence of sufficient transportation competition to enable the negotiation of adequate rates and service terms; and 5) the relative costs and efficiencies of transportation alternatives.

The ability to design and implement a transportation plan and related equipment and infrastructure that can move large volumes of bulk material in a timely, efficient manner takes on great importance for the Hudson River project, where each day of the dredging season, large volumes of material must be dredged, processed, and transported out of the project area. As explained in subsequent sections of this *Preliminary Design Report,* although no decisions have been made to date regarding restrictions on days or hours of operations, it was assumed, for purposes of this Preliminary Design, that average production rates will be in the range of 3,000 in-situ cy per day for 7-day-per-week operation to 4,000 in-situ cy per day for 5-day-per-week operation (based on the need to target removal of 530,000 cy per year during full-scale [Phase 2] dredging). These volumes would translate into the need to transport an average of approximately 4,500 to 6,000 tons per day of processed material. Such a production schedule would require the loading and movement of 45 to 60 100-ton rail cars every day, either 5 or 7 days a week, for the entire dredging season. Therefore, sufficient transportation infrastructure, equipment, and commitments from carriers must be available to move this material without delays or interruptions. Accordingly, achieving the USEPA's productivity standard will hinge not only on the design and construction of sufficient infrastructure in the project area, but also in large part on the ability to obtain enforceable equipment and cycle time performance standards from railroad and barge service providers. This issue is particularly important in railroad transportation, where there is a general lack of competition between carriers, combined with limited regulatory relief for railroad service deficiencies.

Yet another component of the transportation element that will affect the overall design of the project is the facility or facilities that are chosen for final disposal. Several transportation factors will have a bearing on the selection of a disposal facility location, namely: 1) access to the facility by transportation providers capable of providing services to the project; 2) capacity and equipment requirements at the facility; and 3) ability of the facility to handle and process deliveries from the project in a safe and efficient manner. For example, a particular disposal facility might be able to support all of the project disposal needs, but might not be served by a railroad compatible with the facilities at the Hudson River, or the disposal facility might only accept waste that is delivered in certain equipment, thereby forcing adjustments to the dredging and processing elements of the project in order to use that facility.

Finally, many of the design considerations that apply to outbound processed material also apply to inbound backfill and other project materials. The backfill design aspects are discussed in more detail in Section 11.

Some of the specific considerations and constraints regarding transportation are discussed below, organized into in-river and land transportation considerations.

4.5.1 In-River Transportation Considerations

Barging is an acceptable option for transporting processed material for disposal, and the extent to which barges may be used to transport processed material for disposal is being explored. Additionally, barging and other in-river transportation methods will be evaluated as part of the dredging and dredged material transport elements of the project design. This sub-section discusses the primary in-river transportation issues, such as canal logistics, increased vessel traffic due to construction vessels, and coordination with commercial/recreational vessels.

4.5.1.1 Canal Logistics

The Champlain Canal lock system poses several constraints on the use of barges and other vessels for the project. For example, the canal has a speed limit of 10 miles per hour unless otherwise posted. The lock dimensions are approximately 328 ft by 45 ft and the horizontal clearance for vessels is approximately 300 ft by 43.5 ft. Seven locks are located in the three sections of the river to be dredged, with each “lockage” (i.e., a single lock cycle that allows one or more vessels to pass through a lock in one direction) taking on the order of 24 to 30 minutes. These constraints will affect the speed, number, and size of the vessels that can be used. In addition, the hours of canal operation must be considered in the design. For example, according to NYS Canal

Corporation records, the lock closing time during 2003 was 10:00 pm (earlier during the first 2 weeks and the last 4 weeks of the season), and a minimum of 24-hour notice is required for off-hour lock passage.

The navigational depth of the channel must also be considered in sizing of the equipment. As indicated in Section 3, bathymetric data are available to determine the available navigational depth and will be considered in the project design. Nevertheless, the ROD (USEPA, 2002a) indicates:

- "Dredging of the navigation channel, as necessary, to implement the remedy and to avoid hindering canal traffic during implementation;" and
- "To help ensure that navigation is not impeded, EPA will consult with the NYS Canal Corporation during RD and construction phases on issues related to canal usage, navigational dredging, and other remedy-related activities within the navigational channel."

In both the Phase 1 and Phase 2 Intermediate Design stages, construction vessel traffic simulations for dredging and restoration scenarios will be developed, and meetings will be held with the NYS Canal Corporation to define and ultimately establish protocols for, or otherwise resolve, the following issues critical to Phase 1 and Phase 2 activities:

- Lock opening and closing dates required to support the Hudson River project;
- Lock operating hours by lock and by day of week through the operating season required to support the Hudson River project;
- Planned or estimated typical un-planned lock downtime, due to maintenance or other activities, that could interfere with project implementation;
- Restrictions or special provisions that may apply to construction vessels and materials being transported on the canal system; and
- Priority of construction-related vessels versus recreational traffic.

The NYS Canal Corporation regulates activities in the canal system and has promulgated regulations governing navigation in the canal system (21 NYCRR Part 151). The NYS Canal Corporation administers a permit program for the use or occupancy of canal lands (21 NYCRR § 156.4). The *Phase 1* and *Phase 2 Intermediate*

Design Reports will include specifications to satisfy the substantive requirements of this permit program, to the extent it applies to the party performing the RA, as discussed in Section 13.

The NYS Canal Corporation also issues permits to allow vessels to use the NYS canal system and locks. The NYS Canal Corporation uses the permits to track the number of vessels that pass through the locks and to provide a semi-quantitative estimate of annual canal usage. Permits are required for commercial craft, and user fees are imposed (6 NYCRR § 150.2). The permitting program does not apply to the RA because it is being performed pursuant to the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The user fees may need to be paid to the extent that they apply to the construction vessels associated with the RA.

4.5.1.2 Construction Vessel Considerations

Numerous construction vessels will be required to implement and support the Hudson River project, including tugs, barges, support workboats, dredges, sampling boats, and others. These vessels will present an increase over the normal commercial/recreational vessel traffic, resulting in a corresponding increase in lock usage. Further, three other considerations need to be taken into account in assessing the potential for operations to create congestion and interference with river traffic, namely: 1) the varying lateral area (i.e., width) across the river occupied by dredging and support vessels and resuspension control process options; 2) the presence of pipelines carrying dredged material and associated booster pumps; and 3) the required in-river berthing area (for both unloading and loading of barges/scows and for associated support vessels) at the land-based processing facility(ies). The type and number of construction vessels required on the river for each dredge area during each construction season will be estimated during both the Phase 1 and Phase 2 Intermediate Design stages. The design approach for in-river transport is described in more detail in Section 7.

Specific details on navigation within this project will be developed in coordination with the NYS Canal Corporation during the latter stages of design. As part of the RD process, it is important to understand how the presence of construction vessels may affect all vessel movements throughout the canal system. It may be possible from time-to-time to schedule vessel movement during remedy implementation in a manner that accommodates known periods of heavy traffic or minimizes construction vessel use in sections of the canal (e.g., between specific locks) during known periods of heavy use. Knowledge of the number and types of vessels, as well as the occurrence of high traffic periods throughout the Champlain Canal, will be useful in that regard. Additional details on navigation will be discussed and protocols coordinated with the NYS Canal Corporation during the Phase 1 and Phase 2 Intermediate and Final Design stages.

4.5.2 Land Transportation Considerations

In the 2002 ROD, the USEPA determined that dredged and processed material would be transported out of the project area for disposal by rail or barge, and not by trucks. The use of barges for this purpose is discussed briefly above and in more detail in Section 7. The selection of rail as the means to transport sediment over land is a significant design challenge for a number of reasons. First, more infrastructure exists in the project area to support truck transportation than rail transportation. The preliminary assessment of new rail infrastructure that would be required to achieve the USEPA's production objectives is provided in Section 9 and Appendix 9-A. Moreover, as stated above, the large daily volumes of materials that would have to be transported makes critical the negotiation of transportation terms and conditions that ensure that transportation providers adhere to the established cycle times and performance obligations, and enable consistent compliance with the project schedule. Delays or interruptions in rail service of even several days will adversely affect the entire project. Under the present state of the U.S. railroad industry and regulatory environment, meaningful commitments from carriers are the exception, not the rule. Indeed, only the largest rail shippers with the direct rail-to-rail competition at their facilities are able to obtain enforceable service performance standards.

The ability to obtain railroad service reliability that is consistent with the project objectives will be essential to being able to meet the project's productivity standards. The inability to obtain such reliability will adversely affect all aspects of the project. These and other land transportation issues are discussed in more detail in Sections 9 and 10.

4.6 River Access Needs

River access will be needed in multiple locations to support remedial activities. These access areas may be used for the following activities:

- Processing facility locations;
- Land-locked area access; and
- Other access needs.

These are discussed in the following sub-sections

4.6.1 Processing Facility Locations

The locations of the processing facilities will be determined during the USEPA siting process, as explained in the *Hudson River PCBs Superfund Site Facility Siting Concept Document* (Facility Siting Concept Document) (USEPA, 2002b). The location of the processing facility sites, and associated river access locations, must be known to properly design major elements of this project, such as dredging, dredged material transport, sediment and water processing, transportation, disposal, and backfilling/capping.

The USEPA's facility siting process consists of seven major milestones, including:

1. Determining siting criteria (engineering and other considerations);
2. Identifying Preliminary Candidate Sites (PCSs);
3. Screening and evaluating PCSs;
4. Identifying Final Candidate Sites (FCSs);
5. Conducting site-specific field investigations of the FCSs;
6. Recommending site(s) for selection; and
7. Selecting sites.

The USEPA has completed the first five of these milestones, with the sixth (recommended site(s) selection) scheduled for January/February 2004. The Phase 1 site(s) are scheduled to be selected by April 2004, and the Phase 2 site(s) are scheduled to be selected by August 2004. Currently, seven FCSs have been identified, as listed below and depicted on Figure 4-1:

- Energy Park/Longe/NYS Canal Corporation;
- Old Moreau Dredge Spoils Area/NYS Canal Corporation;
- Georgia Pacific/NYS Canal Corporation;
- Bruno/Brickyard Associates/Alonzo;

- NYS Canal Corporation/Allco/Leyerle;
- State of New York/First Rensselaer/Marine Management; and
- OG Real Estate.

During the Phase 1 and Phase 2 Intermediate Design stages, each of the above-listed FCSs will be evaluated with respect to river access (for equipment/material staging and movement, as well as for other project needs). Bulkheads may need to be constructed at the processing facilities, as well as ramps/landing area for moving equipment on and off barges. It is anticipated that the selected processing facility site(s) will be used for equipment and material staging, as well as for equipment access to the river, as it is beneficial to centralize these activities. It is estimated that at least 2 dedicated acres of each site will be needed for material/equipment staging.

River access may also be necessary for restoring shorelines, placing booster pumps, or supporting other logical needs of the project. This issue will be further addressed during the Intermediate Design stage for Phase 1 and Phase 2.

4.6.2 Land-Locked Area Needs

The land-locked area of the Upper Hudson River encompasses 2.3 miles between the Fort Miller Dam (RM 186.2) and Thompson Island Dam (RM 188.5). The Champlain Canal bypasses this entire 2.3-mile stretch by means of the man-made channel along the eastern side of the river. The only access to this area is by foot or via vehicle transportation (i.e., car or truck); therefore, this area poses a significant constraint for getting equipment in and out, and more importantly, transporting sediment out of the river to a processing facility. A number of options will be considered to address this issue, including hydraulic transport and barging, as well as use of trucks, if necessary, for transporting material to the processing facility and rail yard.

An additional river access area (consisting of at least 2 acres) is expected to be needed for equipment staging, and potentially dredged material staging, in the vicinity of the land-locked area. This river access area will provide access for equipment and personnel into these reaches to perform dredging and remove the dredged material from this reach of the river. Additional acreage or separate access may be needed if dredged material is moved ashore for transport to the processing facility. As with the other river access areas, bulkheads may need to be constructed at the selected site(s) for securing landing/ramp areas to launch barges and move equipment on and off the barges. Equipment and material may be moved using a floating barge with a gate that can be raised and lowered, providing a "bridge" to the shoreline and other barges. Additional information regarding transporting dredged material and equipment to and from the land-locked area is provided in Section 7.

4.6.3 Other Access Needs

Other access needs include: labor and equipment access to and egress from the river at strategic points (for construction staging as well as shoreline/habitat replacement and reconstruction); backfill staging and loading; and equipment location (e.g., booster pumps or pipeline routing around locks and dams). River access may also be required for activities that are not currently defined.

Further details of these needs will be determined during the Phase 1 and Phase 2 Intermediate Design stages.

4.7 Construction/Operations Limitations

This sub-section discusses the construction/operations limitations based on time of year, weather conditions, and environmental considerations for dredging, backfilling/restoration, sediment and water processing, and sediment transportation for disposal.

4.7.1 General Limitations on Period of Construction/Operations

Due to weather conditions in eastern New York, field operations will only be conducted from early May through mid-November of each year. For purposes of this Preliminary Design, it is assumed that actual dredging will stop by the end of October, with the remainder of the season to be used for completing the backfilling/capping project element; processing and transporting dredged material; and for shutting down and demobilizing the project for the season. At the present time, the USEPA has not established any restrictions on days or hours of dredging operations (i.e., no decisions have yet been made on this subject). However, given the limited construction season, size of the project, draft productivity standards, and other project constraints discussed above, dredging and associated work (i.e., equipment maintenance, sediment processing operations) may have to be conducted for up to 7 days per week to meet target production rates. For purposes of this Preliminary Design, it has been assumed that operations will occur 5 to 7 days per week, between early May and the end of October for dredging, and into November for associated backfilling/capping, sediment processing, and winterization activities. These assumptions would lead to a required average production rate of 3,000 to 4,000 in-situ cy per day, based on assuming 5 to 7 days of operations per week for 26 weeks and the need to remove 530,000 cy per year during full-scale (Phase 2) dredging. The exact daily duration will not be known until the Phase 1 and Phase 2 Intermediate Design stages, and hence, the assumption of 5 to 7 days in this report is made to account for two possible extremes in the project.

The design will be based on the seasonal operating windows described above first, taking into account river-flow conditions and freezing temperatures, while, in all instances providing for adequate worker health and safety. Each of these latter considerations is discussed below.

4.7.2 River-Flow Conditions

Dredging activities are assumed to be safely conducted in river flows that will not impact vessel anchoring limitations and resuspension control system installations. For example, based on flow data collected at the USGS Fort Edward gauging station from 1930 to 2002 (Table 3-1), river flows in excess of 10,000 cfs (a potentially impacting flow condition) occur approximately 6% of the time during the proposed dredging season. However, closer analysis indicates that during the first 2 weeks of May (approximate start of in-river dredging) the river flow has historically exceeded 10,000 cfs approximately 30% of the time. During the Phase 1 and Phase 2 Intermediate Design stages, appropriate operational flow thresholds will be established, including requisite river-flow monitoring, notifications, and contingencies for shutting down work activities on the river.

4.7.3 Worker Health and Safety

Worker health and safety are high priorities for the project and have been addressed in site-specific *Health and Safety Plans* (BBL, 2003e, f; QEA, 2002b) for sampling and design activities. The RA will consider not only health and safety concerns associated with all activities to be performed as part of the remedy, but also potential worker exposure to hypothermic conditions and slip hazards (especially under freezing conditions when working over water in NYS during early spring and late fall conditions). A *Health and Safety Plan for Remedial Action* (RA HASP) will be developed during the Phase 1 and Phase 2 Final Design stages.

4.8 State of the Practice for Environmental Dredging

The Hudson River dredging project is unprecedented from an environmental dredging perspective, due to the large volume of sediment to be removed (approximately 2.65 million cy), the length of river to be addressed (40 miles), and the need to simultaneously achieve the performance standards and other requirements imposed. This project is further complicated by the process constraints previously discussed, such as a limited construction window, the presence of locks and dams, and the presence of a 2.3-mile-long land-locked area in the Upper Hudson River. Similar standards have not been imposed on any other environmental dredging project. In addition, the final selection of the locations for one or more processing facilities is currently unknown, and infrastructure and other facilities for the reliable transport of dredged and processed material do not currently exist. These constraints make this project extremely complex.

In developing this design, it is critical to consider these constraints in light of the environmental dredging experience gained at other sites. This experience and lessons learned have been presented in the technical literature including:

- *Dredging PCB-contaminated Sediment from the St. Lawrence River: Project Overview* (Esterline et al., 2002);
- *Handbook of Complex Environmental Remediation Problems* (McGraw-Hill; 2001);
- *Environmental Dredging: Methods, Trends, and Case Histories* (Cushing and Hammaker, 2001);
- *Environmental Dredging: An Evaluation of Its Effectiveness in Controlling Risks* (GE, 2000); and
- "Identification and Evaluation of Remedial Dredging Difficulties" (Cushing, 1999).

In addition, GE has developed a comprehensive database of information on completed environmental dredging projects, called the Major Contaminated Sediment Sites database (MCSS database Release 4.0) (GE, 2003).

The lessons learned from this experience are briefly summarized to reinforce the necessity of addressing them in the design approach for each element of this project. An overriding theme is the need to differentiate between navigational and environmental dredging. Failure to make this distinction and rely on navigational dredging experience to develop assumptions for productivity and cost will lead to critical errors in the design. Not recognizing and making use of the available environmental dredging information on lessons-learned will result in a longer dredging project that costs significantly more to implement than planned, and will not be as effective as anticipated. The information regarding completed environmental dredging projects presented in the literature cited above and in the MCSS database (GE, 2003) identifies the following important considerations for design:

- Presence of rocks, bedrock, vegetation, and debris in the dredge area;
- Presence of free oil or dredge-induced sheens in the river;

- High water volumes from dredging and land-based water treatment capacity limitations;
- Shallow water depth;
- Disposal limitations;
- Dredging releases and resuspension controls; and
- Ability to achieve low residual (post-dredge) concentrations.

Each of these factors is discussed briefly below.

Presence of Rocks, Bedrock, Vegetation, and Debris in the Dredge Area

The presence of impediments in the dredge area may greatly slow or even stop dredging. These impediments include rocks or boulders, bedrock or hardpan directly underlying sediments to be removed, vegetation, or debris (e.g., logs, shopping carts) that may be located on or below the sediment surface. This situation is especially problematic when the site has not been sufficiently characterized during design. The presence of large boulders at the General Motors and Alcoa (formerly Reynolds Metals) sites, located along the St. Lawrence River, slowed down dredge production rates and limited the ability to achieve the target residual PCB concentration. Debris also negatively impacted production at the United Heckathorn Superfund Site near San Francisco, California and the Gould Superfund Site near Portland, Oregon. The effect of submerged vegetation on dredge production was also noted on the Grasse River in New York, where an initial step of "weed-clearing" was required to remove SAV prior to dredging. Additional details on these and other projects can be found in the literature referenced above.

The primary lesson learned from these sites is the necessity of completing a thorough characterization of surface and subsurface conditions in the dredge area, including: the location, nature, and size of debris; the presence of SAV; the geotechnical characteristics of the sediment to be removed; and the materials surrounding and underlying the dredge area (e.g., bedrock, boulders, hardpan, or adjoining side-slope areas). In addition, the design should include a process to manage large objects, such as leaving boulders in place as was done on the LTV Steel Site.

Presence of Free Oil or Dredge-Induced Sheens in the River

Sediment in some isolated backwater areas along the Upper Hudson River may contain high concentration of organic matter and PCBs such that floating oil sheens with PCBs may result when sediment is disturbed. However, no evidence exists to suggest that pure mobile PCB oils are present in the Hudson River sediments. At the Bayou Bonfouca, New Bedford Harbor, and Sheboygan River sites, the experience involved free oil, but that experience can be considered in the context of the conditions on the Hudson River. At Bayou Bonfouca, a multi-tiered array of silt curtains was used in combination with a log boom to collect oil floating on the water's surface. At the New Bedford Harbor, the presence of oil was correlated with air-borne PCB levels requiring shut-down of dredging operations (USEPA, 1998). At the Sheboygan River, multiple dredge passes were required to try to achieve low residual PCB concentration due to the presence of oil. After several re-dredging passes, some of these areas were capped.

The lessons learned include the importance of identifying areas where oil sheens containing PCBs may be present so that control measures such as oil booms can be incorporated into the design and the potential for enhanced volatilization evaluated if possible.

High Water Volumes from Dredging and Land-Based Water Treatment Capacity Limitations

High water volumes and the resulting need for significant water treatment capacity can be the rate-limiting factor for a dredging project, particularly if a hydraulic dredge is used. The percent solids generated during hydraulic dredging for an environmental dredging project (typically 3 to 5%) is lower than traditional navigational dredging projects (typically 5 to 15%) due to often shallow depths of cut to minimize volume removed and also operational adjustments to capture resuspended sediment before it migrates away from the point of dredging. Several environmental dredging projects where multi-step treatment operations were required to meet discharge limits include New Bedford Harbor, LTV Steel, Marathon Battery, Bayou Bonfouca, Pioneer Lake, Manistique River and Harbor, Formosa Plastics, and Lavaca Bay. The inability of land-based water treatment to keep up with dredging reduced the overall productivity on the projects. Similar limitations to dredge production have been experienced due to limited land-based solids processing capability.

The primary lesson learned is the importance of appropriate sizing of water treatment operations during the design to meet the peak flow demands of the project. These peak flow conditions are largely driven by the maximum pumping capacity of the dredge(s) (i.e., number and size of dredges), as opposed to an assumed percent solids for the slurry and the solids content of the in-situ sediment. The corollary applies to the solids processing where sizing should be based on appropriate peak solids content.

Shallow Water Depth

Water depth is a critical factor for most environmental dredging projects. The available water depth can limit the type of dredge and transport equipment that work in a given area, or can limit the available work hours due to fluctuating water levels. Changes in water levels may be due to tidal conditions, temporary changes in flow that occur over the course of days to weeks, or more immediate changes in water levels due to man-made structures like dams that could occur over minutes to hours. Experience at the New Bedford Harbor, Marathon Battery, and Alcoa (formerly Reynolds Metals) sites identify water depth as a critical factor affecting productivity. The first two projects were conducted in a tidal setting where dredging was limited to periods of high tide. Equally important was the reduced water depth for the New Bedford Harbor and Marathon Battery sites, which limited the process options for sediment transport (pipelines had to be used since the areas were too shallow for barges).

The need to conduct navigational-type dredging to facilitate the use of barges for sediment transport is highlighted in documentation for the St. Lawrence River dredging project (Esterline et al, 2002). This project required nearly 4 weeks of "navigational-type dredging" to remove rocks and boulders to provide sufficient draft for the barge and tugboats. This ultimately delayed the start of dredging and effectively reduced the overall productivity of the project.

Significant lessons learned include the importance of knowing the available water depth, and the degree to which water depth can change and then using that information for sizing the equipment. Another important lesson learned is to set productivity rates in the design to reflect limitations that available water depth will have on dredging and transport operations. This will include the evaluation of process options to transport dredged material over distances up to several hundred feet from the point of dredging to barges that may be temporarily berthed in the deeper areas of the river.

Disposal Limitations

Disposal is a key bottleneck for some environmental dredging projects; examples include diminishing disposal capacity (and hence, dredge production) as a project nears completion. Another example of the impacts of disposal on dredge production is not having a disposal site and hence, dredging stops or is not started at all. The need for pretreatment to facilitate transport and disposal can also be a limitation. Roughly 50% of the environmental dredging projects evaluated used off-site commercial landfills for disposal; sediment was stabilized prior to disposal for some of these projects.

The lessons learned concerning disposal limitations include several important considerations during design, such as ensuring that a viable disposal facility is in place prior to commencing the project. Others include:

- Ensuring that the available infrastructure and reliable transport means are in place to support disposal operations;
- Having a disposal location but no transport mechanism that matches or exceeds dredging and production rates will affect overall productivity;
- During design, quantifying the steps necessary to dewater the sediment prior to disposal, otherwise, assumptions regarding the dewatering characteristics of the sediment made in the design may not hold true in construction (which could lower the overall productivity); and
- Having sufficient data to correctly estimate the bulking of sediment which is important to both transport and disposal.

Dredging Releases and Resuspension Controls

Dredging releases and resuspension controls are significant factors affecting dredge productivity and the ability to achieve low residuals in the sediment after dredging. Releases during dredging are termed resuspension. During environmental dredging, efforts to control the generation of resuspended sediment (and dissolved phase releases) are sometimes employed at the dredge head. Efforts to reduce resuspension at the dredge head have historically resulted in a lowering of the overall productivity (e.g., slower operation of a mechanical dredge or decreased solids content during hydraulic dredging operations). Resuspension controls (i.e., the efforts to contain resuspension away from the dredge head) include the use of silt curtains, floating booms, geomembrane silt curtains, portable dams, or steel sheeting. These controls have lowered overall productivity due to the amount of time needed to install, re-deploy and work around the control structures during dredging. The effectiveness of these controls is a function of many variables, including the aquatic environment as well as their inherent limitations. For example, silt curtains are generally ineffective in flow velocities greater than 1.5 fps and are difficult to work with in tidal or windy environments. A significant limitation for silt curtains (as documented in the literature cited above) is their inability to control dissolved phase releases. This limitation was measured and documented for dredging projects conducted at both the Grasse and Fox Rivers.

The lessons learned include the importance of considering physical limitations when deploying these controls and keeping them in place during varied flow and wind conditions, the probability that water craft may impact in-river controls, the inability of silt curtains to intercept dissolved phase releases, and the difficulty of installing sheetpile controls in areas with hardpan and bedrock. The design also needs to consider the reduction in productivity resulting from operational efforts to reduce resuspension at the dredge head.

Ability to Achieve Low Residual Concentration

Data regarding the ability of dredging to reduce surficial sediment concentrations are contained in the literature cited above. Within the design process, it is important to include realistic production rates and costs reflecting the lower production and relatively higher cost associated with efforts necessary when attempting to achieve low residual concentrations including the possibility of having to ultimately cap some of the dredge areas that do not meet the target residual levels.

The primary lessons learned from the data on the ability to achieve low residual chemical concentrations include:

- It is difficult to achieve low residual PCB concentrations (on the order of 1 to 5 mg/kg); and
- Re-dredging, including multiple passes (up to 30 times in one isolated case), does not necessarily increase the probability of achieving low residuals.

5. Dredging Design

Dredging is the first of several linked and mutually dependent project elements. As the initial project element to generate material for management, the rate at which dredging proceeds will have a significant impact on the subsequent project elements, including, but not necessarily limited to: the need for and degree of resuspension control, the frequency at which re-dredging will be needed and the amount of solids and water generated for transport, sediment processing and treatment, transportation for disposal (or beneficial use) and disposal (or beneficial use). Given the relationships between these project elements, the type, number, and operational parameters of the dredges selected will have a major influence on the other elements of the project. In turn, these elements will also influence dredging. For example, having limited final transport equipment available will affect the ability to process sediment that may in-turn affect the dredging operation. These feedback relationships and the need to balance daily dredge production, sediment processing, transportation, and disposal, are not resolved at the Preliminary Design stage. Rather, the Preliminary Design is limited to a conceptual evaluation of available dredge equipment. The specific dredge methods will be selected during the Phase 1 and Phase 2 Intermediate Design stages.

This section discusses the following topics regarding the dredging design:

- Basis of design;
- Design approach;
- Preliminary evaluation of dredge equipment;
- Interrelationship with other project elements; and
- Summary.

5.1 Basis of Design

This sub-section describes the technical basis of design for the dredging element, including the project requirements that must be met, KPVs, and design assumptions.

5.1.1 Project Requirements

The project requirements for dredging are set forth in documents prepared by the USEPA including the FS (USEPA, 2000), ROD (USEPA, 2002a), draft Engineering Performance Standards (Malcolm Pirnie and TAMS, 2003), and the Quality of Life Performance Standards (just recently released). The USEPA's FS and ROD identified the removal of sediments primarily on the basis of PCB mass per unit area (MPA). The MPA thresholds are 3 grams per square meter (g/m^2) Tri+ PCBs in River Section 1, and 10 g/m^2 Tri+ PCBs in River Section 2. Sediments in River Section 3 are to be removed if they meet the River Section 2 MPA threshold and exhibit the potential for erosion or continued uptake by biota. The actual dredging locations will be established through sampling conducted under the SSAP, and the locations and depths of sediment removal necessary to achieve these requirements will be presented in the DAD Reports.

The USEPA's draft Engineering Performance Standards provide a primary design requirement for dredging and consist of standards for dredging-related resuspension, residuals, and productivity (see Section 4). These standards are in draft form; if they are changed in final form, the project requirements will reflect that change. The resuspension standard sets action levels based on concentrations of TSS and PCBs in the water column (both in the immediate vicinity and downstream of dredging). The standards also provide tiers of monitoring based on a comparison of water quality data with the criteria presented in the standard. The resulting actions depend on the measured PCB or TSS concentrations and include, in escalating fashion, dredging with baseline monitoring and no additional controls, dredging with additional monitoring, dredging along with engineering controls, and temporarily shutting down the dredging operations. The use of operational restrictions (e.g., limiting dredge-head swing rate) at the dredge to reduce resuspension will tend to decrease dredge productivity.

The draft performance standard requires removal of all PCB-contaminated sediments within areas targeted for dredging, with an anticipated residual of approximately 1 mg/kg Tri+ PCBs (prior to backfilling). The draft standard also allows backfilling or capping in certain situations where the residual exceeds 1 mg/kg Tri+ PCB. In this case, the residual level in the backfill or cap will need to be below 0.25 ppm Tri+ PCB. As described in Section 4, the USEPA has proposed the collection of post-dredging samples to confirm achievement of these residuals. The iterative sampling and evaluation process and the range of additional remedial measures to be taken (depending on the results of the sampling) are described in Sections 4 and 11. The iterative nature of these activities and the length of time between decisions can decrease dredge productivity.

As described in Section 4, the USEPA's draft productivity standard identifies an annual target of 265,000 cy for Phase 1, a target of 530,000 cy per year for the first 4 years of Phase 2, and 265,000 cy in the last year of Phase 2.

As described in Section 4, the USEPA's draft Quality of Life Performance Standards (just recently released) include standards for air, odor, noise, lighting, and navigation. Each of these standards could constrain how (and how efficiently) dredging is implemented and affect productivity.

The requirements to satisfy permit equivalencies (discussed in Section 13) will also be considered when selecting the dredge equipment and designing the dredging methods.

5.1.2 Key Process Variables

The evaluation of dredge equipment is a function of the KPVs described below.

- **Production rate:** This represents the rate of in-situ sediment that a dredge can remove over a given period of time (e.g., cy removed per day). This is a critical process variable since the rate at which sediment can be removed will, in part, set the pace for the other project elements and it is expected that the removal rate will vary over the course of time (i.e., hourly, daily, weekly).
- **Sediment type and consistency:** Sediment type and consistency are important relative to the suitability of a dredge to remove a particular type or types of sediment. As further described in sub-section 5.3, some dredges have had difficulty digging in certain types of sediment including consolidated sands, gravels and cohesive clays. The suitability of a dredge to remove certain sediment types may dictate the potential need to switch dredges, thereby creating a negative effect on productivity.
- **Solids percent by weight:** This represents the relative amount of solids in the sediment-water mixture removed during dredging. The amount of water that different dredging process options (e.g., mechanical dredging versus hydraulic dredging) add to the in-situ sediment during dredging varies significantly. There is typically much less water to transport and treat with mechanical dredging as compared to hydraulic dredging.
- **Horizontal accuracy:** This represents the accuracy of the dredge in the "x-y" dimensions and is important relative to the ability of a dredge to work around shoreline structures, remove debris, and minimize the overlap between dredging passes. The latter is important to minimize the amount of sediment that the dredge misses during the removal process and minimize the amount of non-targeted sediment removed during

dredging. This results from the horizontal accuracy of the dredge, as well as the locational system employed with the dredge (e.g., global positioning system [GPS] guided systems).

- **Vertical accuracy:** This represents the accuracy of the dredge in the "z" dimension and is important relative to the ability of a dredge to successfully remove the targeted sediment while minimizing the amount of non-targeted sediment removed (i.e., minimizing over-dredging). This results from the vertical accuracy of the dredge itself, as well as the locational system employed with the dredge (e.g., GPS guided systems).

- **Maximum water depth:** This refers to the maximum water depth in which the dredge can effectively work. For dredging in the Upper Hudson River, this will not be a significant variable given the relatively shallow water depths (i.e., typically less than 20 ft).

- **Minimum water depth:** This refers to the minimum water depth in which the dredge can effectively work. For dredging in the Upper Hudson River, this will be a significant variable given the substantial amount of area to be dredged in shallow water depths (i.e., water depths less than 3 ft).

- **Sediment resuspension:** Sediment resuspension refers to particles of sediment which are dislodged into the water column by the dredging process. This is an important variable because actions implemented to minimize sediment resuspension may decrease productivity. Certain actions to reduce resuspension (for example, increasing the dredge cycle time for a mechanical dredge or reducing the swing speed or depth of cut for a hydraulic dredge) will reduce the productivity of a given dredge.

- **Dredging residuals:** This refers to concentrations of PCBs left in the bottom sediment after removal of sediments by dredging. The ability of the dredge to achieve low residual PCB concentrations is an important variable that directly influences the ability to minimize both the time and effort associated with re-dredging and also the additional sediment that re-dredging generates.

- **Barge transport:** Barge transport of dredged materials must be compatible with the dredge type. Barge transport is an important KPV given the constraints for transporting sediment in the Upper Hudson River. For example, barges can be used to transport mechanically dredged sediment, but are not applicable for transporting hydraulically or pneumatically dredged sediment, except in some limited applications. As a result, if barges provide the only practical means of transporting dredged material to the processing facility, hydraulic dredging will be viable only under limited circumstances (see Section 7).

- **Pipeline transport:** Pipeline transport of dredged material is the alternative to barge transport, and must be compatible with dredge type. Hydraulic pipeline transport is an important KPV given the constraints for transporting sediment in the Upper Hudson River. For example, pipelines can be used to transport sediment dredged by a mechanical, hydraulic, or pneumatic dredge. However, as discussed further in Section 7, the pipelines are intrusive and have a practical distance limit.

- **Positioning and propulsion control:** The type of positioning control and propulsion systems used for a dredge (e.g., spuds or cables) can affect sediment resuspension, possibly interfere with navigation, and directly affect the horizontal and vertical accuracy of the dredge.

- **Maneuverability:** This refers to the ease of moving and relocating the dredge as it operates. This is an important process variable since each time the dredge is re-located, the production rate is lowered or ceased.

- **Portability:** This represents the level of effort required to mobilize the dredge to the project location. For example, the portability of a dredge may be a limiting factor that precludes certain dredges from accessing the land-locked area of the Upper Hudson River.

- **Availability:** The availability of the dredge in the marketplace, including potential limitations on importing foreign built hulls into the United States (imposed by restrictions under the Jones Act), is an important process variable. Also important is the extent to which the dredge is available in the marketplace and the lead time needed to construct dredges specifically for this project.

- **Presence of debris and loose rock:** Debris and loose rock are impediments to efficient dredging. The extent to which the dredge can remove or work around the range of debris expected to be present in the Upper Hudson River (including natural items such as trees, logs, cobbles, and boulders; as well as other items such as bottles, cans, tires, shopping carts, cars, and sunken watercraft) will have a direct impact on production rate. These items will cause sediment resuspension during their removal and impede the normal operation of the dredge (e.g., preventing a dredge bucket from completely closing and causing loss of sediment out the bottom as it is lifted through the water column, or interfering with a hydraulic dredge head and pipelines). As a result of these difficulties, debris removal operations typically precede dredging, but may not be successful for buried debris and rocks.

- **Flexibility for varying conditions:** Flexibility represents the ability of the dredge to work in different river environments, including changing water depths and sediment types. This is an important process variable because the less flexible a dredge is in handling variable conditions, the more likely that multiple dredge types will be needed to complete the project. Use of multiple dredge types will decrease productivity due to moving the different pieces of equipment in and out of the dredging operation and increase the size of the dredge fleet, with associated increased logistical issues. This added complexity and fleet size is undesirable.

- **Thin lift/residual removal:** The ability of a dredge to remove a relatively thin layer of sediment, such as the residual sediment subject to re-dredging is an important process variable relative to minimizing over-dredging (i.e., minimizing the quantity of sediment removed in relation to the initial target volume).

- **Hardpan/bedrock:** The presence of hardpan/bedrock close to the bottom of the dredge prism greatly decreases the ability of a dredge to remove the overlying sediment. It is also an impediment to vessel anchoring and installation of resuspension controls. This is an important process variable as it is difficult to achieve efficient production rates and ultimately low residual PCB concentrations in such areas.

- **Shoreline/in-water structures:** The range of in-river structures includes bridges, locks, and dams that could be damaged during the dredging process, or present a potential risk to construction workers and equipment. Other structures located in the river, including water in-takes, outfalls, and cables, are also important to the evaluation of dredge equipment. The ability of a dredge to work in proximity to the shoreline (including bank areas) and in-river structures will be a factor in dredge production.

- **Surface water flow characteristics:** The selected dredge will be required to operate over a range of flow and wave conditions that may be influenced by precipitation, wind, or man-made influences (e.g., dam and lock operations). The accuracy of dredging can be affected in high-wave conditions and some dredge types are not suitable to high velocity environments (i.e., cable-supported clamshell bucket).

- **Presence and type of vegetation:** The effect of the presence and type of vegetation in and along the river is an important KPV since it will influence dredge selection and aid in determining whether or not actions are necessary to remove the vegetation prior to dredging. Along the Upper Hudson River, vegetation generally ranges from sparse in some areas to well-developed in others. In locations where vegetation exists, it includes various grasses, shrubs, and trees of all stages of development. Most of this vegetation is expected to be located near the shoreline; although, in locations of lower flow velocities and at times of higher flow conditions, it may extend away from the shore as large SAV beds.

5.1.3 Design Assumptions

The following assumptions were used for developing the Preliminary Design for the dredging project element:

- Sediment volume targeted for removal is 2.65 million cy. This sediment volume will be updated during the Phase 1 and Phase 2 Intermediate Design stages using information from the DAD Reports. Consistent with this approach, the assumed locations and removal depths for these sediments are taken directly from Plate 17, Figures 1 through 7 of the USEPA's 2000 FS (included as Appendix 5-A to this *Preliminary Design Report*). Note that this will be refined during the Intermediate Design once the DAD Reports are approved by the USEPA.

- No work hour or workday restrictions for dredging are included. Given the limited construction season, the size of this project, and other project constraints discussed in Section 4, it is assumed that dredge equipment may have to be operated up to 7 days per week to meet the target production rates (for the purpose of illustration in the Preliminary Design).
- The production rate for the project is assumed to range from 3,000 to 4,000 cy per day (assuming 530,000 cy of annual removal from early May through the end of October every year; either 7-day or 5-day per week operation). Note that the maximum instantaneous dredging production rate must be higher than these nominal rates, as a contingency for downtime, but will be bounded by practical storage reserves and production rates of sediment processing, transport and disposal operations. Also, these assumptions are only used as points to illustrate concepts at this Preliminary Design stage. The evaluation of limitations made to the days or hours of operation will be completed during later design stages.
- Specialized dredges and other specialized equipment will be needed to manage debris, in-river obstructions, vegetation, and shoreline stability prior to and during dredging. This issue will be addressed during the Phase 1 and Phase 2 Intermediate Design stages, along with the specific locations and depths of dredging established through the DAD process.
- Dredges (mechanical, hydraulic or pneumatic) and qualified operators will be available as needed, as well as associated support equipment (e.g., tugs, barges, scows) and labor.
- Mechanical dredging will generate an additional 20 to 30% water by volume, over and above in-situ water content of the sediments that will require transport and processing.
- Hydraulic dredging will produce an average dredged material slurry ranging from 3 to 5% solids by weight.
- Mechanical dredging with slurry transport will produce a material slurry ranging from 20 to 30% solids by weight.
- Re-dredging passes, if needed, will produce a dredged material slurry ranging from less than 1 to 3% solids by weight.
- Dredging in areas with sensitive habitat and cultural resources will be evaluated in the Phase 1 and Phase 2 Final Design stages.

As the design progresses, these assumptions will be validated and modified as appropriate.

5.2 Design Approach

The overall approach for the dredging design is consistent with the RD Work Plan (BBL, 2003a) and includes development of preliminary drawings, an overall dredging strategy, and information for process flow diagrams (PFDs). Because the DAD process is still underway, the overall removal volume identified in the FS (i.e., 2.65 million cy) (USEPA, 2000) has been used for the purposes of this Preliminary Design, including the preliminary PFDs. The areas and depths proposed for dredging in the FS were presented as a series of figures (Plate 17, Sheets 1 through 7) that are also included in Appendix 5-A to this report. When the DAD Reports are approved by the USEPA, a series of drawings will be developed presenting the areas and depths targeted for dredging. These DAD footprints will then be used to develop the dredge prisms that will be included in the *Phase 1* and *Phase 2 Intermediate Design Reports*. To provide an understanding of the type and level of information that will be included in the dredge prism drawings, a sample prism for a hypothetical dredge area is included as Figures 5-1 through 5-3.

The removal areas and associated sediment volumes and draft Engineering Performance Standards provide the primary basis of design for the dredging project element. The basis of design is needed to develop the outputs from this project element that form the process inputs for the resuspension control and the dredged material transport project elements. The preliminary PFD reflects these inputs and outputs for the project as a whole, and is presented in Section 2. The PFD is built upon in Section 8, where the volume of sediment to be removed, the volume of water and sediment to be generated during the dredging, the additional water volume to be generated during transport (if any), the outputs from the processing facility in terms of the millions of gallons of water to be treated each day, and the tons and cy of processed material to be transported from the processing facility location to the ultimate disposal site are estimated. The location(s) of the processing facilities were not considered at this stage of design because the siting process has not been completed. They will be an important component of the Phase 1 and Phase 2 Intermediate Design stages.

5.3 Preliminary Evaluation of Dredge Equipment

Dredging involves the removal of sediment using mechanical, hydraulic or pneumatic dredges. The process to evaluate dredge equipment for the Preliminary Design is based on the approach presented in Palermo et al.

(2003) and focuses on evaluating the site-specific characteristics of the Upper Hudson River, the operational attributes of dredge equipment, and a number of selection factors relating to the project requirements (including the performance standards). This approach also recognizes that a balance will need to be reached in selecting a particular dredge type or combination of dredges for the project (i.e., one perfect dredge or combination of dredges may not exist). The operational characteristics considered include potential production rate, percent solids by weight, horizontal and vertical accuracy, and maximum and minimum water depths. The equipment selection factors include sediment resuspension (including chemical release), ability to achieve low residual PCB concentration following dredging, dredged material transport methods (i.e., barge or pipeline), positioning control and maneuverability of the dredge, portability, availability, potential impacts of debris/ loose rock, or hardpan/ bedrock, shoreline/ in-water structures, surface water flow characteristics, and presence and type of vegetation. These factors are also consistent with the characteristics identified in Herbich (2000); Mohan (1998); National Research Council (NRC) (1997); and USEPA (1994) and the state of the practice and lessons learned enumerated in sub-section 4.8.

The preliminary dredge evaluation considered information from the FS (USEPA, 2000) and Responsiveness Summary (USEPA, 2002a), the SSAP and historical sampling programs and a wide range of literature sources including: EPRI (1999); McLellan and Hopman (2000); Parchure (1996); PIANC (1997); SEDTEC (1994); and USEPA (1994). Selected websites were also researched and information from dredge equipment manufacturers and dredging contractors was compiled. It should be noted that this information cannot be directly applied to the Hudson River project without considering site specific differences.

The results of the preliminary dredge evaluation are presented below, organized according to the three process options for dredging (i.e., mechanical, hydraulic, and pneumatic). This preliminary evaluation is also summarized in Table 5-1, where the overall list of dredging process options including multiple sub-process options are evaluated with respect to the KPVs for dredging the Upper Hudson River. Table 5-1 is an evaluation matrix where the relative capabilities and limitations of the dredges are considered in light of the site characteristics presented in Section 3 and the environmental dredging lessons learned presented in Section 4. For each KPV and dredge, a qualitative rating is given including H (high), M (medium) or L (low). For those cases where the KPV does not apply to the particular dredge, the matrix includes N/A indicating that the variable is not applicable to the dredge for the Upper Hudson River. Several of the dredges evaluated in Table 5-1 are not discussed below, since they have limited application to the Upper Hudson River. A summary of the dredges that may be suitable to this project, including their capabilities and limitations, is presented in Table 5-2.

5.3.1 Mechanical Dredges

Mechanical dredges remove sediment by applying direct force to dislodge and excavate materials. Common mechanical dredge types include dragline, clamshell, dipper, and bucket ladder. Of these mechanical dredges, enclosed versions of the clamshell dredge are typically used for environmental dredging projects (USEPA, 1994) because the other mechanical dredges typically create high volumes of resuspended sediment.

Mechanical dredges are typically crane-operated and located on a barge or pontoons. They can also be operated from land to remove sediment that is close to the shoreline. Dredge buckets can also be mounted on traditional excavators (e.g., instrumented backhoes) that can be operated from either the shoreline or a barge. In the United States, bucket sizes of 1 to 10 cy are common; however, buckets up to 40 cy are available on a more limited basis and, when available, have been used for navigational dredging projects. For dredging the Upper Hudson River (i.e., dredge cuts of 2 to 3 ft typically), bucket sizes ranging from 2 to 6 cy would be most applicable.

To remove sediment, the dredge bucket is lowered through the water column with its jaws in the open position, and the bucket is allowed to sink due to its own weight and momentum into the sediment. The jaws are then closed around the sediment, the bucket is raised through the water column, and the sediment is typically off-loaded to a barge/scow for transport. Hydraulic transport using positive displacement pumps can also be used to transport mechanically dredged sediment (discussed further in Section 7). Although mechanical dredges are designed to remove sediment at or near in-situ density, water is typically entrained in the dredge bucket as it closes and is lifted up through the water column and some of this entrained water can be lost from the bucket back into the waterway.

The mechanical dredge buckets being considered for the Upper Hudson River are further described below and include conventional clamshell, wire (or cable) supported environmental clamshell buckets, articulated buckets (a variation of the environmental clamshell), and amphibious excavator. A discussion of excavation in the dry is also included as it may be relevant to some limited portions of the river.

5.3.1.1 Conventional Clamshell Dredge

Conventional clamshell dredges are often used on navigational dredging projects to remove bulk sediment. Their primary application for environmental dredging projects is the removal of debris prior to dredging because of the high level of sediment resuspension associated with their use and their inability to remove a thin or precise horizontal layer of sediment (Herbich and Brahme, 1991). The crater-like shape created by a conventional clamshell bucket can result in significant over-dredging to achieve a target elevation. Sediment resuspension associated with their use is due to physical disturbance of sediments as the bucket enters and is withdrawn from the sediment as well as leakage from the bucket. Leakage occurs when material that escapes through the bottom of a bucket with jaws that are not completely closed and where sediment overflows from the top of the bucket as it is pulled up through the water column. Given these limitations, use of this dredge bucket is limited to debris removal operations or the removal of large rocks and boulders. The primary capabilities and limitations of this dredge are listed in Table 5-2.

Using this type of dredge may be suitable for debris removal, as well as for navigational dredging (of sediment with very low PCB concentrations) to support project execution. The bucket sizes will vary based on the water depths and size of debris present.

5.3.1.2 Environmental Clamshell/ Wire Supported Dredge

Some of the limitations associated with the conventional clamshell (see Table 5-2) can be reduced by modifying the bucket (Hayes et al., 2000). Modified clamshell dredges are often equipped with features to minimize sediment resuspension including:

- Rubber gaskets and instrumentation to improve the seal when the bottom and top seals close and the bucket is lifted up through the water column;
- Buckets that form a flat bottom when closing, and allow the sediment to be removed in layers; and
- Use of differential global positioning system (DGPS) and geographic information system (GIS) technology to precisely locate the dredge head.

Environmental clamshell buckets are typically deployed on the end of a cable from a crane and the bucket is relatively light weight and does not have teeth. Representative examples include the Cable Arm dredge bucket depicted in Appendix 5-B and the Boskalis Horizontal Closing Environmental Grab (Palermo et al., 2003). While these buckets are readily available and generally versatile, their effectiveness has been questionable in some field studies and using these buckets imposes certain important limitations (McGraw-Hill, 2001; Cushing and Hammaker, 2001). One limitation is the extended dredge cycle time associated with efforts to accurately locate the dredge bucket over the specific dredge area and to conduct the dredging process that is slower by design to minimize disturbance of the sediment. The typical cycle time for an environmental dredge could range from 2 to 8 minutes (Cushing and Hammaker, 2001 and Wang et al., 2000). These cycle times are significantly longer than experienced during navigational dredging projects. Cycle time will likely be further increased during windy conditions, when the relatively light-weight cable-suspended bucket could move in the wind resulting in positioning difficulties.

Debris can also be problematic for this dredge bucket as it is for conventional buckets, preventing the jaws from closing completely and allowing sediment to leak from the bottom of the bucket. The size of the dredge bucket is largely a function of the water depth available for the support barge and thus dredging in shallow areas can be constrained by the lack of necessary draft and not sediment removal needs. Use of rubber gaskets in place of teeth on the jaws of the dredge bucket reduce the digging capability of the dredge, and limit the effectiveness of the dredge in certain sand and gravel beds. One approach to compensate for this limitation is to let the dredge bucket freefall through the water column. While this may assist in sediment removal operations, it increases the amount of sediment resuspended. As a rule of thumb, these dredge buckets can remove soft silts and sand but have difficulty digging into sediment with Standard Penetration Test (SPT) value over 3 blows per ft (Wang et al., 2000). Cohesive material should be avoided as well due to the tendency of this material to adhere to the sidewalls of the bucket and may require the use of a rinse tank to remove the material before the dredge bucket is placed back into the water. This variability in performance depending on sediment type is an important consideration in situations where sediment type varies, since it will typically take 1 to 3 hours to change out a dredge bucket (e.g., a different size or type of bucket).

To achieve the production rates established in the draft Engineering Performance Standards, multiple environmental clamshell dredges would be required. This conclusion is supported by data from the Alcoa Site (formerly Reynolds Metals), where three of this type of dredge operating on two 10-hour shifts per day (three buckets operating on the first shift and one on the second shift) could only achieve a combined removal rate of approximately 870 cy per day. This production rate is lower than that achieved on the Lower Saginaw River, where it took a single dredge using two different environmental clamshell buckets (a 6- and 16-cy bucket) in combination with four conventional buckets (4-, 5-, 8-, and 10-cy buckets) operating one at a time to remove an average of 1,130 cy per day (Cushing and Hammaker, 2001). No target was set for residuals on the Saginaw River project and accordingly production was not constrained by confirmation sampling. These two projects also provide information on this dredge type relevant to other project elements. Data from the Alcoa-Massena Site also demonstrates the difficulty of achieving low residual PCB concentrations (the PCB cleanup level at that site was 1 part per million [ppm] PCBs). Following the initial dredging pass, 50% of the dredge cells required re-dredging, and 40% required three or more dredge passes (Esterline et al., 2002) to reach completion. In some cases, cells were capped in lieu of additional dredge passes, while some other cells were dredged up to 10 times. To minimize water quality issues, the dredge area was separated from the river using a sheetpile structure. The primary capabilities and limitations of this dredge type are listed in Table 5-2.

This dredge type is primarily suitable for areas of the Upper Hudson River with fine-grained sediment. This dredge will be further evaluated during the Phase 1 and Phase 2 Intermediate Design stages. Available data being collected as part of the SEDC Program will be used in this evaluation.

5.3.1.3 Articulated Mechanical Dredge

Several dredge buckets fit under the broad term of articulated mechanical dredges, including the Hydraulic Profiling Grab, Ham Visor Grab, Seaway, and DryDredge (see Appendix 5-B). These dredges are operated using traditional or modified barge-mounted backhoes. The geometry of the backhoe and DGPS instrumentation are used to control placement of the dredge bucket. Typical dredge buckets range in size from 1 to 6 cy and can be operated in water depths ranging from 3 ft to over 50 ft, depending on the size of the backhoe arm. Areas of lesser water depths may be dredged provided there is sufficient water depth to meet draft requirements for the support barge (with the appropriate backhoe mounted on the deck) within reach of the backhoe boom.

Operations of the various buckets identified above are all slightly different, but all are designed in a similar manner to remove sediments at or close to their in-situ water content. These dredge buckets take a horizontal cut and many include hydraulic mechanisms to minimize the impact of debris on closing of the dredge bucket. The fixed nature of the bucket as an extension of the backhoe reduces its susceptibility to wind and current. Once the sediment is dredged, it can be loaded directly onto the barge or into an adjacent scow. Some of the dredges are also designed with on-board equipment to receive the sediment. This equipment typically includes a bar screen for debris removal and a high solids pump for transporting the sediment to a processing facility or disposal location. The Seaway dredge is also designed to provide on-barge stabilization and uses an adjoining barge or scow to stabilize the dredged sediment.

Productivity with these dredges may be a limiting factor as many of the dredges have not been used in a setting with project requirements similar to those for this project. Of these dredge buckets, the Hydraulic Profiling Grab has been used to varying degrees at sites including the New Bedford Harbor. At the New Bedford Harbor, productivity is estimated to have averaged approximately 800 cy per day during a pre-design field test where 2,300 cy of sediment were removed over a 4-day period using a 4.5-cy bucket. This daily estimate is an extrapolation assuming a 20-hour workday and the average hourly productivity of 41 cy per hour that was experienced during the operational phases.

The primary capabilities and limitations of the articulated mechanical bucket dredge are outlined in Table 5-2. This dredge bucket is considered to be suitable to the Upper Hudson River. The degree of applicability will be a function of the proximity of the sediment removal layer to the underlying bedrock. Applicability to the Upper Hudson River project will be evaluated during the Phase 1 and Phase 2 Intermediate Design stages. Available data being collected as part of the SEDC Program will be used in this evaluation.

5.3.1.4 Amphibious Dredges

Amphibious dredges may be suitable to a range of environments including upland, aquatic, or transitional areas, such as fringe wetlands or tidal mudflats. The dredge can operate using either mechanical or hydraulic equipment to remove the sediment, which is then hydraulically pumped to a scow or a disposal facility. A major advantage of using this type of dredge is its versatility. It is self-propelled, both on land and in water; and it can operate in the shallower areas of a site, which are inaccessible to many other types of dredges (Normrock Industries, 2001). Primary application of this dredge is for shoreline areas where there may be a variety of wetlands, mud flats, or very shallow areas with standing water. Although amphibious dredges can be used in open water, in a manner that is somewhat similar to typical hydraulic dredges, their production capacity is much less than that of a typical hydraulic dredge because of their small size (which is the feature that provides versatility).

The capabilities and limitations of this dredge are summarized in Table 5-2. The small size of the amphibious dredges allows them to be easily transported on a flatbed trailer which may lend to their use in the land-locked area of the river. However, the commercial availability of some of these types of equipment may be limited by import restrictions under the Jones Act (USEPA, 1987). At this stage, the suitability of this dredge is expected to be limited to shoreline, wetland, and backwater areas and will be evaluated further in the Phase 1 and Phase 2 Intermediate Design stages.

5.3.1.5 Excavation in the Dry

Excavation "in the dry" is typically accomplished by isolating the area of sediment to be excavated using methods such as earthen embankments, sheetpile wall systems, or portable dams. To minimize impacts during construction, the excavation area is often divided into a series of cells, and each cell is excavated individually. Once the area is isolated, the water within the excavation area is removed to create a "dry" environment. After the water is withdrawn, the sediment can be removed with standard earthmoving equipment such as a backhoe, clamshell, bulldozer, or excavator. Even with the water removed, the sediments may be too wet for immediate disposal, and in such cases will require land-based conditioning (e.g., stabilization or dewatering) prior to disposal. Dewatering of the sediment can also be accomplished through the addition of stabilization agents to the sediments prior to excavation. This in-situ stabilization method was used at the Pine River project in Michigan. While the addition of stabilization agents may increase the workability of the sediment, it will also increase the overall mass of sediment to be removed and disposed.

The isolation of the portion of the river's cross-section targeted for excavation could impact navigational and recreational river traffic, and cause localized increases in surface water velocities that may increase erosion potential for adjacent river banks and structures. This may serve to undermine the existing structures or cause flooding under elevated flow conditions. Given these concerns, application of this sediment removal technique is limited to select portions of the Upper Hudson River that lend themselves to hydraulic isolation (e.g., shallow backwater areas and shallow near shore areas).

5.3.2 Hydraulic Dredges

Hydraulic dredges use centrifugal pumps to remove and transport sediment in a slurry form. The dredges are typically barge-mounted and have a suction device fixed to a moveable arm (or ladder) that is raised or lowered to facilitate sediment removal. The suction end of the dredge is often equipped with a mechanical or hydraulic device to loosen the sediment prior to being drawn into the dredge suction line. The most common types of hydraulic dredges are plain suction, cutterhead, horizontal auger and diver-assisted suction dredges. Of the hydraulic dredges listed in Table 5-1, the ones most suitable to the Upper Hudson River include plain suction (diver-assisted), cutterhead, and horizontal auger dredges. These more suitable dredges are described below.

5.3.2.1 Plain Suction Dredge

Plain suction dredging is the simplest form of hydraulic dredging and uses suction created by a centrifugal pump to dislodge and transport sediment. The suction line can be placed on a ladder to control the dredging depth. The dredge is typically operated in a straight-line manner using a cable and winch system, although hand-held suction lines are implemented using divers.

Two environmental applications of the plain suction dredge are the modified dustpan and matchbox dredges. The modified dustpan was developed by the USACE for use in removing free-flowing granular sediment from the Mississippi River. This dredge uses high-pressure water for loosening sediment and a dustpan-shaped dredge head that is nearly as wide as the hull of the dredge (Hayes, 1986). Given the range of fine- and coarse-grained sediment in the Upper Hudson River and the presence of debris, the modified dustpan would have limited application to the Upper Hudson River. The matchbox dredge head was developed by Volker Stevin Dredge of the Netherlands and was used to remove chemical-containing sediment from First Petroleum Harbor (USEPA, 1994). The matchbox dredge head is designed with several features including:

- A triangular cover to limit the dispersion of sediment, inflow of excess water and released gases;
- A funnel to guide sediment towards the intake; and
- A hydraulically controlled flat-bottomed dredge head to remove the sediment in horizontal layers.

The matchbox dredge was tested by the USACE at Calumet Harbor, Illinois, in 1985 and found to be similar to a cutterhead dredge in terms of sediment resuspension, but with a greater degree of vertical control (Hayes et al., 1988). The dredge was also tested at the New Bedford Harbor and appeared not to have any significant advantages over the readily available cutterhead dredge (Otis et al., 1990). Based on this, the matchbox dredge appears to be more suitable to the Upper Hudson River (in certain unique circumstances) than other standard hydraulic dredges.

A low-production suction dredge can also be used underwater by a diver. It is important to differentiate this application, which has an extremely low production rate compared to the other suction dredges described. This technique was included the initial response action for the Duwamish Waterway in Seattle, WA, where 260 gallons of PCB-containing transformer oil spilled into the river. The technique reportedly recovered approximately 30% of the oil initially released (USEPA, 1984). The technique was also used at the Cumberland Bay Site in Plattsburg, NY where divers were deployed with hand-held hydraulic dredges to conduct re-dredging passes. This dredging was conducted to remove residual materials left behind after initial dredging was conducted with a horizontal auger dredge. The technique was also attempted at LTV Steel in Indiana for production passes, with very unsatisfactory results. The primary capabilities and limitations of this dredge are listed in Table 5-2.

The potential use of plain suction dredges for the Upper Hudson River is expected to be limited to diver-assisted re-dredging operations. Plain suction dredging would only be implemented if the primary dredge method is unsuccessful in achieving the USEPA's draft residuals standard. Using this dredging equipment is considered suitable to the Upper Hudson River (especially for dredge areas near in-river structures) and will be further evaluated during the Phase 1 and Phase 2 Intermediate Design stages.

5.3.2.2 Cutterhead Dredge

This dredge is the most commonly used dredge in the United States (Hayes et al., 1988) for navigational and maintenance dredging and can remove a wide range of materials. The dredge can also pump the dredged sediment long distances for processing or disposal. The dredge typically uses a rotating basket or cutterhead to dislodge the sediment before it is drawn into the suction line. An example of a cutterhead dredge is presented in Appendix 5-B.

Similar to plain suction dredges, the size of a cutterhead dredge is defined by the diameter of the discharge side of the suction pump. The dredge is controlled in the field by combinations of spuds, anchors, and cables. These have the potential to interfere with river operations if the dredge is operated in or near the navigational channel. Cutterhead dredges ranging in size from 12-16 inches are suitable for the Upper Hudson River. Based on other environmental dredging projects, production rates for these dredge sizes range from 22 to 60 cy per hour (Wu and Hayes, 2000; Cushing and Hammaker, 2001). While cutterhead dredges are capable of generating slurries with solids concentrations of 10 to 20% on a weight basis (USACE, 1983), using this equipment for environmental dredging typically lowers solids concentration. This is because of the additional water that is drawn into the dredge in an effort to minimize both resuspension and depth of cut (to minimize volume removed). As a result, the slurry concentrations can be as low as 3 to 5% solids (Otis et al., 1990). Despite being operated to minimize resuspension, releases from the dredge area may occur. This was documented by the USEPA and the USACE for dredging at the New Bedford Harbor (USEPA, 1997). During implementation of this project, water column measurements at a downstream bridge indicated the flux of PCB increased by a factor of two to 10 over pre-dredging conditions. The method of propulsion for this dredge can also create windrows in the dredged surface. The cutterhead swings on an arc as it moves from side to side during the dredging process. This action creates windrows where certain sediments targeted for removal may be left behind.

The primary capabilities and limitations of the cutterhead dredge are listed in Table 5-2. The cutterhead dredge is expected to be suitable to the Upper Hudson River with the possible exception of areas with shallow bedrock. The applicability of this dredge to these environments will be further evaluated during the Phase 1 and Phase 2 Intermediate Design stages.

5.3.2.3 Horizontal Auger Dredge

The horizontal auger dredge is equipped with spiral augers that cut the sediment and move it laterally toward the center of the augers where it is picked up by a suction pipe. The dredge removes the sediment in horizontal layers, and can be operated in relatively shallow water depths ranging up to 20 ft deep. A horizontal auger dredge manufactured by Mud Cat™ (a Division of Baltimore Dredges) is depicted in Appendix 5-B. To reduce turbidity, a shroud can be used over the auger head. A heavy duty centrifugal diesel powered pump typically pumps the dredged sediment to a processing or disposal facility. The dredge is typically moved along the water's surface using a winch and wire system, which may interfere with recreational and commercial vessels when working in the Upper Hudson River. While alternative propulsion systems are available, their operation can excessively resuspend sediment.

Horizontal auger dredges have been used for several environmental dredging projects including Manistique Harbor, Cumberland Bay and Fox River (Deposit 56/57). At the Manistique Harbor project, an innovative horizontal auger dredge fitted with two suction pumps was used. At these sites, production rates have ranged from approximately 260 to 1,270 cy per day, with an average of approximately 750 cy per day. It is important to recognize that the upper end of this production range as defined by the Cumberland Bay project included the use of multiple dredges and did not have a target residual PCB concentration for the sediment following dredging. The lower end of the production range is defined by the 6-year Manistique Harbor project, where the production was driven by three additional years of dredging that were needed to attempt to reach the residual PCB target of 10 mg/kg.

Similar to other hydraulic dredges used for environmental dredging, the horizontal auger produces a relatively dilute slurry requiring processing and water treatment. These dredges are designed to reduce resuspension impacts by taking in additional water, however, chemical releases may still occur. However, the substantial horizontal length of the auger head, with pump suction in the center, reportedly leads to substantial loss of resuspended sediments (i.e., not captured by the pump) from either end. Data collected for the Fox River (Deposit 56/57) Site demonstrated statistically significant increases in both dissolved and particulate PCB concentrations during dredging. This was also confirmed by a mass balance study conducted in parallel with the project by the USGS, which reported a 2.2% loss of PCBs (as measured outside the silt curtains) to the water column during dredging (USGS, 2000).

The primary capabilities and limitations of this dredge are listed in Table 5-2. The horizontal auger dredge is potentially suitable for the non-navigational portions of the river. The need to maintain passage for non-project vessels in the river may be inconsistent with the system of cables and cable-supports needed to propel this dredge. The suitability of this dredge will be further evaluated during the Phase 1 and Phase 2 Intermediate Design stages.

5.3.3 Pneumatic Dredges/High Solids Pumps

Pneumatic dredges use compressed air and/or hydrostatic pressure to remove sediment. An important characteristic of their design is the ability to remove sediment at or near in-situ solids content. Common pneumatic dredges include the Pneuma, Airlift, and Oozer dredges. Since these dredges operate on similar principles, they are being discussed in this section as a single process option along with high solids pumps. Details on the capabilities and limitations on the individual pneumatic dredges are presented in Table 5-2. From a productivity perspective, these dredges range from 15 to 125 cy per hour (Palermo et al., 2003). In debris-prone areas, a screen may be needed to decrease the potential for clogging. These dredges can also have difficulty with consolidated sediment deposits and can have difficulty working in shallow water (needing a certain amount of water head to operate properly). In addition, their availability in the United States is limited and there has been limited experience with them on environmental dredging projects in the United States. While the resuspension potential for these dredges is reportedly relatively low, there are not sufficient quantitative data in the literature to support a decision regarding the ability of these dredges to attain the performance standard identified for the Upper Hudson River. The dredge slurry produced by these dredges can make barge transport inefficient as water is typically entrained during the dredging process. In addition, like all dredges discussed herein, debris can interfere with the operation of these dredges.

A pneumatic dredge was used in the demonstration project for Collingwood Harbor, Ontario, Canada (Environment Canada, 2003). Over the 2-year test period, approximately 10,000 cy of sediments containing PCBs and metals were removed. The dredge was lowered into the water column by a barge-based crane and the dredged sediment was pumped through a floating pipeline to a disposal area. Limited data are available regarding the resuspension and residuals achieved during the project, other than that the dredge operated within the turbidity limits established for the demonstration project. It was also noted that the presence of debris increased the water content of the dredged material slurry.

Examples of high solids pumps include the Eddy and Toyo pumps, as well as the Tornado Motion Technology dredge (Tornado). While the operational theory behind each of these dredges is somewhat different, they are designed to remove sediment at or near its in-situ solids content. These dredges are typically deployed from a barge. Some are mounted on a fixed frame such as the Eddy pump and Tornado, while others such as the Toyo are lowered on a cable from a barge-based crane. Depending on the size of the dredge, the barge-based equipment that supports these dredges can be substantial, requiring water depths of 5 to 6 ft to maneuver.

The USACE and USEPA used the Eddy pump for a demonstration project on the Great Lakes with sediment PCB concentrations ranging from non-detect to 10 mg/kg. This project was conducted during from 2000 until 2001 for sediments in a canal adjacent to the Indiana Harbor. After removal, sediments were pumped to large settling basins for dewatering and disposal. Daily production rates averaged approximately 300 cy. Little data are reported in the literature regarding sediment resuspension and residuals associated with use of the Eddy pump. The large size of the dredge and support barge used on the Indiana Harbor canal project would limit the applicability of this specific dredge unit on the Upper Hudson River. Similar to other pneumatic/high solids pump dredges, transport of the dredged sediment is typically accomplished by pumping through a hydraulic pipeline. Transport by barge/scows is not efficient on a large scale due to the volume of material that would need to be barged and the associated logistical issues.

The Toyo pump was recently used to remove 30,000 cy of soft sediments from the Hylebos Waterway in Tacoma, Washington. These pumps have discharge sizes ranging from 4 to 16 inches (Javeler Construction Co., Inc., 2003) and are often used to pump-out sludge lagoons. Little quantitative data have been reported regarding the amount of sediment resuspended by these pumps. While these are not typical dredging equipment per se, these pumps appear to have applicability for sediment transport and may be suitable for transport of dredged material from barge to scow, or for scow offloading at the processing facilities.

The primary capabilities and limitations of these dredges are listed in Table 5-2. The dredges appear to have some applicability to the Upper Hudson River, yet the limitations (including the general lack of quantitative performance data for residuals and resuspension) could limit their use. The limitations will be further evaluated during the Phase 1 and Phase 2 Intermediate Design stages.

5.4 Interrelationship with Other Project Elements

Dredging has a high degree of uncertainty and variability surrounding its implementation that touches every aspect of the project. The inputs and outputs of the dredging project element are illustrated on Figure 2-2, which clearly indicates the critical nature of this element. Key inputs to dredging include the location, type and volume of sediment to be removed, as well as many key site characteristics including water depth, river hydraulics, proximity to shoreline and the navigation channel, and the potential presence of debris, shoreline structures, in-water structures, bedrock or hardpan, and vegetation. Other inputs include the draft Engineering Performance Standards, the draft Quality of Life Performance Standards (just recently released), and equipment availability, as well as the outputs of other project elements including: 1) the potential dredged material transport method(s), which is an output of the dredged material transport process; and 2) the location, layout, and limitations of the processing facilities, which are outputs of sediment and water processing.

Similarly, many of the output parameters from dredging are the key input variables to subsequent project elements, as illustrated on Figure 2-2. For example, the dredged sediment solids concentration and volume of material removed are inputs to the dredged material transport element. Estimates of TSS, turbidity, and dissolved-phase constituents, as well as selection of dredge(s) type, dredge operational methods, and dredge production rate, are inputs to the resuspension control element. The dredge operation is a critical input to sediment and water processing, while the dredge production rate also indirectly influences sediment and water processing (through its effect on the dredged material transport rates input). The water depth, bottom elevations, and conditions after dredging are inputs to the backfilling/capping and habitat replacement and reconstruction project elements.

In addition to these relationships, the feedback from the other project elements to dredging is critical to the project as a whole. Examples include the unavailability of scows or rail cars to transport processed material which could shut down sediment processing operations that in-turn would have a negative effect on dredging including the possibility of shut down. In summary, the dredging project element is intimately interrelated to dredged material transport, resuspension control, sediment and water processing, backfilling/capping, habitat replacement and reconstruction elements and transportation for disposal or beneficial use.

5.5 Summary

The preliminary dredge evaluation process for the Upper Hudson River has identified potential dredges that may be suitable to remove the estimated 2.65 million cy of PCB-containing sediment. These dredges include several sub-process options under the more general process options of mechanical, hydraulic, and pneumatic dredges. Based on the capabilities and limitations of these dredges (Table 5-2), the site characteristics data presented in Section 3, and the lessons learned from other environmental dredging projects presented in sub-section 4.8, the findings of this evaluation include:

- Based on the limited production rates for the individual dredges, the large size of this project, construction season constraints, the productivity performance standard, and the other project constraints discussed in Section 4, multiple dredges operating simultaneously will likely be needed.
- Dredges that have difficulty penetrating dense or compacted sands and gravels may not be suitable for some areas of the Upper Hudson River. This includes environmental clamshell buckets that are relatively light weight and have limited digging capabilities.
- The use of traditional clamshell dredges is limited to debris removal operations and navigational dredging (of sediment with very low PCB concentrations) to support project execution.
- The use of hydraulic and pneumatic dredges is not suitable for removal of sediment containing significant debris because the debris may clog hydraulic transport lines.
- Diver-assisted suction dredges are suitable only for limited applications, including potential re-dredging operations.
- Excavation in the dry may be suitable for isolated or backwater areas of the Upper Hudson River.
- Amphibious dredging equipment is suitable only for shoreline areas of the Upper Hudson River.
- More than one dredge type will be required, since a single dredge process option (or sub-process option) is not suitable for all areas or situations that will be encountered in dredging the Upper Hudson River.
- Mechanical dredges will be required for debris removal.
- Based on the limited production rates for the individual dredges, the large size of this project, construction season constraints, the productivity performance standard, and the other project constraints discussed in Section 4, multiple dredges operating simultaneously will likely be needed.

The results of the preliminary evaluation of dredges for the Upper Hudson River project are summarized in Table 5-3, below.

Table 5-3 – Summary of Dredging Endpoints for Preliminary Design

Process Option	Retained Sub-process Options
Mechanical Dredges	Articulated Mechanical Bucket Conventional Clamshell[1] Amphibious[2] Environmental Clamshell Excavation in the Dry[3]
Hydraulic Dredges	Cutterhead Hydraulic Horizontal Auger Diver-Assisted Suction[4]
Pneumatic and Other Dredges Types	Pneuma Toyo Eddy Pump Tornado

Notes:
1. Conventional clamshell limited to debris removal operations and navigational dredging (of sediment with very low PCB concentrations) to support project execution.
2. Amphibious dredge limited to shoreline portions of non-navigational areas.
3. Excavation in the dry limited to isolated or backwater portions of non-navigational areas.
4. Diver-assisted suction dredge limited to re-dredging operations.

During the Phase 1 and Phase 2 Intermediate Design stages, the dredge evaluation/selection process will be refined using the data collected as a part of the DAD process, including where and how much sediment will be removed. With the locations and depths of dredging known, along with the locations of the land-based processing facilities, a more complete evaluation of the KPVs identified above will be conducted using the data collected pursuant to the SSAP, available data from the SEDC Program, and treatability studies. All of the dredges currently identified in Table 5-1 will be reconsidered (as necessary, based on information obtained in the meantime), as well as any new dredging equipment or other relevant information that becomes available in the interim.

6. Resuspension Control

Resuspension control process options, or physical methods to reduce the transport of sediment and PCBs which are inevitably resuspended during dredging, may be needed in some areas to meet USEPA's Engineering Performance Standard for resuspension. This *Preliminary Design Report* presents the results of the initial screening of resuspension control process options that could apply to the Hudson River project. This section primarily addresses resuspension resulting from dredging operations. Resuspension from other in-river activities (e.g., installation and removal of sheetpiles, anchoring systems/spuds, propeller wash) are not addressed. It is assumed that such activities will be managed by careful and prudent field operation procedures and will be subject to the requirements in the Resuspension Performance Standard.

This section primarily assesses structural resuspension control process options, which are physical structures that can be employed to limit migration of sediment resuspension generated by the dredge. Operational controls implemented at the dredge, which include the choice of dredge type, dredge-head modifications, and/or modifications in dredge operational mode (e.g., cut speed, angle, depth) will be covered in the *Phase 1 and Phase 2 Intermediate Design Reports*. Specific topics covered at a Preliminary Design level in this section include:

- Basis of design;
- Design approach;
- Evaluation of resuspension control process options;
- Estimation of system efficiencies;
- Preliminary selection of resuspension control process options;
- Process option framework for Intermediate Design;
- Interrelationship with other project elements; and
- Summary.

6.1 Basis of Design

This sub-section presents the technical basis for the resuspension control process options, including the project requirements, KPVs, and design assumptions.

6.1.1 Project Requirements

The project requirements for resuspension control process options are set forth in several documents prepared by the USEPA including the ROD (USEPA, 2002a), Engineering Performance Standards (Malcolm Pirnie and TAMS, 2003), and Quality of Life Performance Standards (just recently released). The ROD (USEPA, 2002a) establishes the underlying requirements for selecting areas to be dredged, which will be refined through the DAD process that will identify the areas of the river where resuspension control process options must be considered.

One goal of the resuspension control design is to satisfy the Engineering Performance Standard for dredging-related resuspension. As discussed in Section 4, the USEPA's draft resuspension standard establishes four levels of water quality criteria with respect to RA activities – the Standard, and Evaluation, Concern, and Control levels. Action levels for the near-field sampling (i.e., within 100 m [300 m in River Section 2]) are established in terms of TSS, and action levels for far-field sampling are established in terms of TSS and PCB concentrations (total PCB) as well as PCB loading. These requirements are discussed further in Section 4, with a more complete description in the draft Engineering Performance Standards (Malcolm Pirnie and TAMS, 2003).

Surfacewater monitoring data collected from near-field and far-field locations will be compared to the action levels to determine what, if any, action is required. The range of resulting actions in sequence includes: 1) dredging with no additional controls or monitoring; 2) additional monitoring; 3) additional engineering solutions; or 4) temporarily halting dredging. The draft resuspension standard fundamentally assumes that no containment will be applied (although, according to EPA, only average concentration and sediment texture conditions were assumed) and that potential resuspension control process options will be considered as engineering solutions, if needed.

As described in Section 4, the USEPA is also expected to issue water-quality-based limitations on releases of constituents, which will affect the selection of resuspension control process options. In addition, the USEPA's Quality of Life Performance Standards may also affect the selection, design, and installation of the resuspension control process options.

6.1.2 Key Process Variables

The selection of specific resuspension control measures will depend on a number of KPVs, as summarized below.

- **Bathymetry:** The depth of water and topography of the riverbed will be important factors for the selection and sizing of the resuspension control process options.
- **River velocities and directions:** This variable will affect the advection of resuspended solids, turbidity, and dissolved-phase PCBs, as well as the selection and sizing of the resuspension control process options.
- **Riverbed geotechnical characteristics:** These characteristics include the strength and compressibility of riverbed sediments, depth of bedrock at the river bottom or within its close vicinity, and presence of boulders, rip-rap, and other debris in the river. These factors will affect the selection and sizing of the resuspension control process options.
- **Sediment particle size:** This variable will affect the time that particles resuspended during dredging remain in suspension. Sediment particle size may also affect the extent to which the adsorbed PCBs partition into the dissolved phase.
- **Sediment PCB levels:** Sediment PCB levels will affect the PCB concentrations in resuspended sediment (as well as dissolved in the water column).
- **Turbidity generation potential (source strength) of dredge equipment:** This variable will affect the area and volume of sediment being disturbed and the extent of sediment resuspension during dredging.
- **Dredged material transport:** During dredged material transport, vessels may need to enter and exit the dredge area and travel parallel to the resuspension control system. These movements must be accommodated in the design of the resuspension control process options, specifically their selection, sizing, and performance.
- **Backfill requirements:** After dredging is complete, backfill/cap material will be placed. The type of material to be placed and placement methods will influence the selection and sizing of the resuspension control process options as well as the duration that these process options will be left in place.
- **Navigational requirements:** This variable accounts for requirements when dredging in or immediately adjacent to the navigational channel.

6.1.3 Design Assumptions

The following assumptions were used for developing the Preliminary Design for resuspension control:

- PCBs are the primary constituents of concern, and hence the primary driver for resuspension control.
- Dredging may be performed at multiple locations simultaneously.
- In-river operations will be performed between early May and mid-November, when ice formation and ice movement are not expected; therefore, the design of this project element will not consider loads and effects associated with ice.
- Dredging will at times occur in the navigational channel.
- Dredged material will be transported to land-based processing facilities either by barges (scows, other types of vessels) or by hydraulic pumping through pipeline(s).
- Upon the completion of dredging, resuspension controls will remain in place, if needed, until backfill/cap placement is completed.
- Areas to be dredged are as presented in the FS (USEPA, 2000).

6.2 Design Approach

The overall approach for designing the resuspension control process options presented here is consistent with the RD Work Plan (BBL, 2003a), and includes the development of conceptual drawings and the preliminary selection of resuspension control process options for the Hudson River project. As discussed in Section 5, once the DAD Reports are approved by the USEPA, a series of drawings will be developed during the Phase 1 and Phase 2 Intermediate Design stages presenting the footprints (areas and depths) for dredging to achieve the applicable removal criteria. These footprints will be used to develop the general layout of resuspension control process options (if needed) around the dredge areas. These drawings will be included in the *Phase 1* and *Phase 2 Intermediate Design Reports*.

When evaluating the need for or designing the details for the resuspension control project element, the relationship between the KPVs will be established, such that the effectiveness of resuspension controls can be better understood. The confidence level in determining the need for and selecting the appropriate process options will be directly related to the confidence in this relationship.

Two fundamental methods can be used to control resuspension in the water column:

- Controlling the agitation caused by the dredge equipment (i.e., controlling the turbidity generation potential), which typically involves a modification in the operational mode of dredging (adjusting production rate, dredge depth, dredge angle as discussed in Section 5) or, on a more limited basis, adding a shroud to the dredge head; and
- Controlling or reducing the migration of suspended solids and associated constituents by selecting and installing an appropriate resuspension control process option, discussed further below. The three main functions of resuspension control process options are: 1) isolate the dredge area; 2) reduce the inflow to the dredge area; and 3) capture the components associated with turbidity and TSS, thus controlling the downstream plume.

This *Preliminary Design Report* presents a conceptual approach for selecting potential resuspension control process options, while leaving the specifics of the resuspension control system selection process to the Phase 1 and Phase 2 Intermediate Design stages when dredge areas and types of dredges are known. The steps of this conceptual approach are summarized below:

- **Evaluate available resuspension control process options**: The logistical and schedule constraints for the installation of resuspension control options will first be evaluated. Next, using available information, the technical practicability of placing, operating, and maintaining the available resuspension control options will be determined. Additional engineering information will be collected as part of the SEDC Program. Available results will be incorporated into the Phase 1 and Phase 2 Intermediate Design stages.

- **Evaluate the performance from other projects:** Using the MCSS database (GE, 2003) and other available information, the performance of various resuspension control process options (in particular the efficiency of the process options to reduce the migration of suspended solids, turbidity, and dissolved contamination from the dredge area) was reviewed and evaluated.

- **Evaluate the system efficiency of resuspension control process options:** Based on the evaluation of the performance of common resuspension control process options (as observed on other environmental dredging projects), as well as other information available from manufacturers, vendors, and independent design or research studies, the efficiency of typical resuspension control process options has been initially estimated. This initial assessment also identified the common constraints among the resuspension control process options.

- **Preliminarily select the resuspension control process options for the typical river sections:** Based on evaluation of the resuspension control process options, their performance as observed on other projects, their potential efficiency, their interaction with other project elements, and the river environment encountered, the available resuspension control process options have been narrowed down to a list of control process options retained for consideration during the Phase 1 and Phase 2 Intermediate Design stages.

- **Develop an appropriate design process framework:** The framework to be utilized during the Phase 1 and Phase 2 Intermediate Design stages was developed during this Preliminary Design stage.

- **Assess the interaction of the resuspension control process options with other project elements:** Other project elements directly interact with the resuspension control project element; these interactions were identified and evaluated.

These steps are discussed in more detail in the following sub-sections.

6.3 Evaluation of Resuspension Control Process Options

Several different types of resuspension control process options were considered during the Preliminary Design stage. The types of resuspension control process options include those that have been used at other environmental dredging projects as well as those being developed by various vendors. Table 6-1 describes the resuspension control technologies used in other environmental dredging projects and provides an evaluation of their effectiveness in those projects.

The resuspension control options evaluated during Preliminary Design include:

- No containment;
- Silt curtains;
- Sheetpile walls; and
- Other resuspension control process options such as king piles, caissons, air curtains, and portable dams.

Table 6-2 presents the results of a simple comparative evaluation of how effective each type of resuspension control system might be in addressing the KPVs presented in sub-section 6.1.2, above. Table 6-2 represents a first step in the design process that is described in sub-section 6.2

6.3.1 No Containment

The no-containment option is a resuspension control process option where the dredge area is not isolated from the rest of the water body by physical means, and the control of resuspension relies entirely on the operational controls of the dredge. These may include controlling dredge production rate, dredge depth, dredge-head positioning, dredge movement, and ancillary machinery movement and operation (e.g., vessels, spuds, anchors).

Several dredging projects have been recently conducted where using resuspension control process options was reduced or eliminated, including the sediment remediation projects for the Head of Thea Foss Waterway (Utilities, 2003), Thea Foss & Wheeler Osgood Waterways (City of Tacoma, 2003), Pacific Sound Resources (USACE, 2003a), and the St. Clair River (Dow, 2002). Three of these four projects are in marine environments. Appendix 6-A provides project examples where hydraulic and mechanical dredging operations were implemented with the no-containment process option selected, and where only dredge-head controls were used, if at all. Other project examples are listed in Table 6-1, where no resuspension control was used during the project execution. Considering the conditions at these project examples, the following general observations can be made:

- The river or tidal current velocity at these projects was generally in excess of 6 fps.
- The dredging occurred in waters with depth ranging from 5 to 50 ft.
- In some cases, the navigational traffic was heavy, with numerous pleasure craft and large marine vessels passing near the dredging operations.
- In most cases, water quality monitoring typically included TSS and turbidity monitoring only. Little information is available on monitoring with respect to chemical parameters.

For the projects mentioned above, the use of silt curtains would have been problematic due to high current velocities, and the use of sheetpile walls would have been inappropriate due to the navigational requirements and water depths. Table 6-2 presents a qualitative ranking for the no-containment process option illustrating how adequately it addresses the KPVs.

6.3.2 Silt Curtains

Though silt curtains have been used in river environments to control resuspension, their use is limited to lower-velocity areas. Silt curtains usually involve the use of filter fabrics or impervious polyethylene sheets combined with flotation and anchoring devices. Filter fabrics are relatively light and therefore easy to place and move, and allow exchange of water across the fabric. Impervious sheets provide greater isolation, most environmental dredging projects where silt curtains were chosen used impervious sheets.

Typically, single silt curtains are used to surround the entire dredge area. In some cases, mainly in flowing water, dual (or even triple) silt curtains are used whereby the outer silt curtain decreases the velocity of the water, and the inner curtain provides most of the turbidity containment. Dual silt curtains also provide flexibility by allowing dredges and barges to move from the dredge area to the shore by alternating the position of the opening in the curtains while maintaining continuous (overlapping) containment. Silt curtains have also been used to isolate smaller work areas within a larger sheetpiled work area.

Silt curtains are usually deployed using small vessels, barges, or tugboats, and are anchored to the shore to buoys and/or to the river bottom. The inherently flexible and re-locatable nature of silt curtains is particularly useful to address a wide variety of dredge area conditions. Silt curtain containment process options should be configured around the dredge area to allow appropriate clearance for the dredge. Figure 6-1 shows the typical construction details for silt curtains, while Figure 6-2 shows a potential conceptual layout and configuration of silt curtain containment process options for typical project scenarios likely to be encountered during the Hudson River project.

When evaluating the use of silt curtains, the following factors will be considered:

- Silt curtains are relatively inexpensive, and can be relocated or reused.
- A wide variety of turbidity barriers and silt curtains are available.
- Installation of silt curtains may be impractical in water depths greater than 20 ft.

- Silt curtains provide containment near the water surface for suspended solids; however, dissolved flow and solids underflow will occur.
- Silt curtains are generally limited to use in lower-velocity environments due to damage to the fabric or sheet caused by high-velocity currents. In addition, flaring of the curtain due to the high velocity significantly increases underflow. The practical upper limit of river velocity with respect to silt curtain applicability, as documented in the literature and by equipment suppliers, is estimated at 1.5 fps.
- Properly selected anchors allow the use of silt curtains in a broad range of riverbed situations.
- Silt curtains are typically positioned 1 or 2 ft above the bottom and are rarely fixed to the bottom (to prevent ripping and to allow passage of the water).
- Reasonable working distances from dredges must be maintained since the dredge head may damage the silt curtain.
- Wind and changing river depths need to be accommodated.
- Silt curtains may be used when dredging occurs in or near navigational areas, because silt curtain booms represent relatively little, although not insignificant, risk to vessels.

One possible way to increase the efficiency of silt curtains, which will be investigated during the Phase 1 and Phase 2 Intermediate Design stages, is to use submerged weirs, which could be useful to control the underflow. The submerged weir technology is being developed for the control of reservoir sedimentation at dams, which is important to water resource management and hydro-power generation (Oehy, 2002).

Inflatable dams and weirs, also known as rubber-dams, have been used for runoff control or as small cofferdams or adjustable weirs (Chanson, 2003). An inflatable dam could be installed as a submerged weir in an effort to control a suspended solids plume propagating along the river bottom and thus provide resuspension control in conjunction with or in lieu of silt curtains. Inflatable submerged weirs can be installed in shallow bedrock areas, or where utilities or debris would otherwise make the installation of sheetpile walls impractical. While no precedent at environmental dredging projects exists, this technology will be further evaluated during the Phase 1 and Phase 2 Intermediate Design stages.

Guidelines for the selection and design of silt curtain process options are provided in USACE (1997), and in design guides published by manufacturers and vendors (e.g., Parker Process Options, Inc., 2003 and Elastec/American Marine, 2003).

Table 6-1 contains information on large-scale environmental dredging projects that utilized silt curtains as the primary resuspension control system. Table 6-2 presents a qualitative ranking for the silt curtain process option illustrating how adequately it addresses the KPVs. Appendix 6-A provides a project example where a single silt curtain was used to separate the dredge area from open water, and Appendix 6-B provides a list of some of the main silt curtain suppliers and manufacturers with their contact information.

6.3.3 Sheetpile Walls

Sheetpile walls have been used in general marine construction for in-water works to isolate work areas and serve as a structural component of wharfs, bulkheads, etc. Sheetpile walls involve the connection of steel panels along their edges using a thickened edge on the panel inserted into a groove along the edge of the neighboring panel, so that a continuous and nearly impervious steel wall is constructed. Larssen (U shape) and Frodingham (Z shape) sheetpiles are most commonly used. Numerous connection details have been developed by various manufacturers to ensure strength and impermeability at the joint between two neighboring sheetpile wall panels (Pile Buck, Inc., 2003a). A detailed description of commercially available sheetpile walls can be found in Pile Buck, Inc. (2003b). In addition to the conventional sheetpile walls, high-strength plastic sheetpile walls have recently been introduced.

Sheetpile walls are usually installed by driving the panels into the river bed using vibratory or impact (hammer) drivers. Sheetpile walls are typically installed adjacent to and outside the limits of dredging so that they do not interfere with dredging. Recently, static installation using hydraulic push technology has also been introduced (Ken-Jet Corporation, 2003). Sheetpile walls have been used on a few environmental dredging projects to contain the increased turbidity and TSS near the dredge from the rest of the water body. Sheetpiles and sheetpile drivers are available from numerous vendors, suppliers, and contractors.

Main factors to consider concerning the use of sheetpile walls include the following:

- Sheetpile walls are relatively costly, and their installation is typically slow.
- The procurement of sheetpiles often requires extensive lead time.
- Sheetpile walls generally provide a high degree of isolation for the dredge area and can be effective to control TSS and turbidity, while minimizing the transport of dissolved-phase contamination.

- Sheetpile walls may be used in high velocity flow areas.
- Sheetpile walls represent an obstruction to river flow, causing change in current direction and velocity that may change the scour characteristics of the river.
- Sheetpiles penetrate deep below the riverbed and therefore could interfere with buried riverbed utilities.
- The presence of bedrock, rip-rap, debris, etc. may impede installation of sheetpiles.
- The installation and extraction of sheetpiles is typically a slow process.
- The installation and extraction of sheetpiles may impact adjacent structures due to vibration.
- The installation and extraction of sheetpiles may cause resuspension of sediment and release of PCBs.
- Noise and vibration are unavoidable during sheetpile installation.
- Sheetpile containment process options do not easily facilitate the passage of vessels (e.g., dredge barges and scows) into and out of the dredge area, requiring the implementation of additional process options such as silt curtains or air curtains across openings in the sheetpile.
- When installed, sheetpile containment process options represent a high level of risk to vessels.
- As observed on other projects, sheetpile traps resuspended contaminated sediment particles within the dredge area; these particles tend to fall back onto the dredged surface, making attainment of low residuals more difficult.

Guidelines for the selection and design of sheetpile wall process options are included in USACE (1990). Figure 6-3 shows typical construction details for sheetpile walls, while Figure 6-4 shows a potential conceptual layout and configuration of sheetpile process options for typical project scenarios likely to be encountered during the Hudson River project. Standard specifications for sheetpile structures are recommended by the United States Department of Defense (1999). The water tightness of the sheetpile wall can be increased (if desired) by modifying the design of the connection or by using sealants. Examples include the SEALwall™ system (Sevenson, 2003), Hoesch (Hammer & Steel, Inc., 2003), and the Waterloo system (Waterloo Barrier, Inc., 2003).

Sheetpile walls are installed by using vibratory, impact, or hydraulic drivers, typically mounted on a barge. Sheetpile walls are usually installed adjacent to, but just outside of, the boundaries of the dredge area, so that their interference with the dredging operation is relatively limited. Sheetpile walls can be installed to completely surround the dredge area, or in conjunction with air curtains (discussed later) or silt curtains, to provide an opening for access to the dredge area for vessels. Sheetpile walls can also be used to protect structures, buildings, and fixtures in the immediate vicinity of the dredge area, which otherwise may be affected by the dredging.

Table 6-1 contains summary information on large-scale environmental dredging projects which utilized sheetpile as the primary resuspension control process option. Table 6-2 presents a qualitative ranking for the sheetpile wall process option illustrating how adequately it addresses the KPVs. Appendix 6-A provides a project example where sheetpile walls were used for containment, and Appendix 6-B contains a list of some of the major sheetpile manufacturers and vendors.

6.3.4 Other Resuspension Control Process Options

To overcome the limitations of the primary resuspension control process options (i.e., silt curtains and sheetpile walls), some innovative technologies have been developed for environmental dredging projects, as described below.

King Pile System

This system is used when the proximity of bedrock or extensive debris on the river bottom makes the installation of sheetpiles difficult or impractical. In this system (the concept of which is shown on Figure 6-5), H piles are driven into the river bottom or drilled into bedrock and metal or fabric (pervious or impervious) sheets are attached to the piles. The sheets may be toed into the river bottom, providing sheetpile-type containment, or the sheets can be installed with a 1- or 2-ft clearance over the river bottom to provide underflow if necessary. King pile process options may require using divers (for riverbed tieback), thus increasing safety risks, cost, and duration of installation.

The king pile system has the following advantages:

- King piles may be suitable when hard bedrock, rip/rap, debris, or underwater utilities would render the installation of sheetpile walls impractical.
- King piles reduce the impact to adjacent structures during installation/extraction.

- King piles reduce resuspension during installation/extraction compared to sheetpile walls since less area of sediment is disturbed during the installation/removal processes.

A king pile system was utilized at the General Motors and Alcoa (formerly Reynolds Metals) sites along the St. Lawrence River in Massena, New York (Table 6-1).

Air Curtains

Air curtain technology involves the creation of a vertical circulation barrier by delivering compressed air to the river bottom and releasing it through closely spaced perforations of the delivery pipe. The released air bubbles rise to the surface to form a vertical barrier (curtain) that restricts the passage of water (including turbidity, suspended and dissolved contamination), but not vessels. Air curtains can be used in conjunction with silt curtains or sheetpile walls to provide a control across a gate (opening) for the transit of barges, scows, and other vessels into and out of the dredge area. Some factors to be considered for air curtains include the following:

- Little data exist on the efficiency of air curtains in controlling resuspended sediment.
- Air curtains require underwater piping connected to an air compressor.
- Air curtains are more effective in shallow, low water velocity environments.

Air curtains were used in conjunction with a king pile process control option at the Alcoa site (formerly Reynolds Metals) in Massena, New York.

Caissons

Where a precise removal of a small sediment volume is required, caissons can be used. Caissons are (usually) circular steel casing (typical diameter = 10 ft) driven into the sediment to facilitate the removal of sediment from inside the casing (Sevenson, 2003). The factors to be considered when selecting and designing a caisson system include the following:

- Caissons allow for more accurate removal of sediment.
- Caissons effectively isolate the dredge area.

- Caissons are suited for working near shoreline structures, although installation of caissons may affect adjacent structures due to vibration.
- Caissons cover a small area and require overlap in dredge areas.
- The rate of dredging needs to be slow; accordingly, caissons are most suitable for projects removing relatively small volumes of sediment.
- Installation and removal of the caisson will cause resuspension.
- Installation of caissons is impeded by bedrock, rip-rap, or debris.

A unique form of caisson dredging is the Seaway Control Zone Technology (Seawaytech, 2003). In this system, a square, practically impervious "pen" is lowered from a barge to establish a containment zone within which dredging will proceed. Water is pumped from inside the containment zone, thus setting up an inward gradient (towards the dredge area), essentially trapping turbidity, TSS, and dissolved phase contamination inside the "pen."

Caisson dredging was used at the Fraser River in Canada for the remediation of a site characterized by a high level of PCB contamination (Ministry of Environment, 2002). For the Hudson River project, this resuspension control system may be considered for small areas of relatively highly contaminated sediment.

Portable Dams

Other innovative products include several proprietary systems such as the Portadam™ and Aqua-Barrier™ for construction site containment, diversion of river flow, erosion control, and flood control. These process options are low-cost alternatives to sheetpiles and relatively easy to set up, disassemble, and relocate. The process option usually involves placing a rubber liner over an angle iron structure (Portadam™) or placing a plastic tube on the bottom and filling the tube with water (Aqua-Barrier™). The water behind the dams can be removed to allow removal "in the dry." Due to the relatively flexible nature of the portable dams, these process options are inherently suitable to follow an undulating river bottom. They can also accommodate debris to a certain extent and typically require little anchoring effort. On the other hand, portable dams are limited to shallow areas and are vulnerable to puncturing. The factors to be considered when selecting and designing portable dams include the following:

- Portable dams generally provide a high degree of isolation for the dredge area and can be effective to control TSS and turbidity, while minimizing the transport of dissolved-phase contamination.
- Portable dams are used generally in shallow water (less than 10-ft depth) near the shoreline; increases in water level or flow can dislodge the portable dam.
- Portable dams may be used in relatively low to moderate velocity flow areas.
- Portable dams do not penetrate below the riverbed and therefore could be used where there are buried riverbed utilities.
- The portable dams can be installed in the presence of bedrock, rip-rap, debris, etc., although puncturing of the portable dam is a consideration.
- The installation and removal of portable dams may cause resuspension of sediment and release of PCBs.
- Portable dams do not easily facilitate the passage of vessels (e.g., dredge barges and scows) into and out of the dredge area.

Table 6-2 presents a qualitative ranking for the various innovative process options (introduced above), illustrating how adequately these process options address the KPVs.

6.4 Estimation of System Efficiencies

System efficiency is traditionally defined as a ratio of turbidity or TSS on the outside of the containment system over the turbidity or TSS on the inside (Elastec/American Marine, 2003). In a broader sense, the system efficiency can be defined as a ratio of any water quality parameter measured on the outside of the containment system over the water quality parameter measured on the inside. In the case of the Hudson River project, PCB concentration in the water column is the critical parameter.

To assess the efficiency of the containment process options, the performance of silt curtains and sheetpile walls at past environmental dredging projects (Table 6-1) was reviewed and various reports on system efficiencies were consulted. On most projects reviewed, the resuspension performance standard was established as a "pass/fail" requirement (i.e., if TSS or turbidity exceedance occurred, it caused shut down of the dredging). Therefore, data are often presented qualitatively; in terms of the action level (performance standard) and whether and how many times it was exceeded. Little quantitative information is available from the projects reviewed.

On most projects evaluated, either no attempt was made or no success was experienced in establishing a correlation between the water quality parameters such as TSS and turbidity. Real-time, frequent measurement of turbidity could serve as an early warning system to alert the contractor of possible water quality impact if such a correlation is established. Further, on most projects, no correlation was established between TSS (or turbidity) and dissolved chemical parameters.

6.4.1 Efficiencies of Resuspension Control Process Options

The following sub-sections provide the results of an evaluation of efficiencies for each type of resuspension control process option being considered for the Hudson River project.

No Containment

The no-containment option has been used at various sediment remediation projects, including those summarized below:

- At the St. Clair River dredging project, a 100-Nephelometric turbidity unit (NTU) trailing hour average turbidity value was established as the resuspension performance standard. Measurements showed that turbidity never exceeded 15 NTU at a distance of about 80 ft (25 m) from the dredge head of a high-vacuum suction dredge (Dow, 2002).
- On the Pacific Sound Resources project, a marine site, mechanical dredging is removing silty clay sediment from a depth ranging from 30 to 50 ft. Water quality measurements currently being taken indicate that turbidity has not exceeded background levels by more than 5 NTU at 200 ft from the dredge head (USACE, 2003a).
- Though no specific data are available, no turbidity or TSS exceedances have been reported for the Manistique River and Harbor and New Bedford Harbor projects after the use of silt curtains was eliminated and dredging was performed without containment.

Silt Curtains

Silt curtain performance on past projects can be summarized as follows:

- Silt curtains were found effective in many cases where the action level was established as 1.5 or 2 times the background turbidity, with essentially no exceedances of the action level during either mechanical or hydraulic dredging (although monitoring frequency was often limited).
- Silt curtains were found effective in cases where the action level was background plus 30 to 50 NTU, with very few exceedances of that level during either mechanical or hydraulic dredging.
- Silt curtain efficiency was influenced not by its primary function, but in some cases by high currents or interference with the bottom. In these cases, the silt curtain system was abandoned and an alternative sheetpile wall system was used (e.g., St. Lawrence River due to high velocities), or no containment was used (e.g., New Bedford Harbor due to interference with bottom).
- At the Welland River in Canada, an impermeable curtain was used (Sevenson, 2003). The background turbidity was 5 Formazin turbidity unit (FTU) and the dredging caused turbidity at the dredge head ranged from 13 to 18 FTU. No turbidity exceedance was observed outside the curtain; therefore, the efficiency may be estimated as a reduction of turbidity from 13 - 18 to 5, based on which a reduction of about 60 to 70% may be postulated.
- Gunderboom reports two projects where relatively detailed measurements of TSS and turbidity were taken to evaluate the efficiency of the Gunderboom PCS™ silt curtain system that utilizes impervious sheets (Gunderboom, 2003). On a creosote-contaminated sediment project, the TSS was reduced from 350 to 12 mg/L with turbidity reduction from 50 to 1.5 NTU. At the Homer project site, the TSS reduction attributed to the resuspension control system was measured as 95%, with turbidity reduction of 90%.
- Insufficient documented information is available on the quantitative effectiveness of silt curtains to contain dissolved phase chemicals.

These observations from past projects generally agree with manufacturer's reported data and recommendations which report that in low-flow regimes silt curtains can achieve 60 to 90% reduction of the turbidity (comparing turbidity inside curtain to turbidity outside).

Sheetpile Walls

The evaluation of the performance of sheetpile walls on past projects can be summarized as follows:

- Since sheetpile walls present an essentially impermeable boundary, turbidity measurements at many project sites were used only to verify the high level of isolation, rather than to quantify the efficiency of the sheetpile wall system
- At those projects where quantification took place (e.g., Alcoa Site in Massena, New York), it was found that the sheetpile wall system reduced turbidity from 25 to 50 NTU (inside the dredge area) to less than 1.5 NTU on the outside of the wall. At the General Motors Site in Massena, New York, though no specific data are available on turbidity reduction, it was reported that the turbidity action level of 28 NTU was exceeded in less than 5% of the water quality monitoring events taken outside the sheetpile wall.

Summary

In the relevant completed project examples, the emphasis of monitoring was on turbidity, and only sometimes on TSS. Even the relatively simple parameters of turbidity and TSS were infrequently or poorly monitored, or the monitoring results were not systematically evaluated and reported. In addition, very little information is available on monitoring the effectiveness of resuspension control process options to control dissolved constituents. Therefore, past projects provide only limited value in guiding the design of resuspension control process options for the Hudson River.

6.5 Preliminary Selection of Resuspension Control Process Options

Based on the evaluation of typical resuspension control process options and their ability to adequately address the KPVs, several of the process control options have been retained for future consideration, during the Intermediate Design stage. These process options, and the river environments for which these process options will likely be considered for the Hudson River project, are described below:

- Using the no-containment process option will be considered for all dredge areas. In such cases, resuspension would be controlled, as necessary, through dredge-head controls. This approach may be particularly applicable for coarse grained sediment areas, where the majority of particles will fall out of suspension within a short time after being agitated, and therefore, the plume will not extend beyond a relatively short distance.
- Silt curtains will be considered for those dredge areas where dredge operational controls may not be sufficient to control the migration of TSS and PCBs, or would reduce productivity to an unacceptable degree. Specifically, silt curtains will be considered for navigational areas (particularly those with fine-

grained sediments) and for dredge areas with less than 20-ft water depth, and where the river current velocities are expected to be less than 1.5 fps.

- Sheetpile walls will be considered for those dredge areas where dredge operational controls may not be sufficient to control the migration of TSS and PCBs. Specifically, sheetpile walls will be considered where river current velocities are expected to be more than 1.5 fps, or where the structural integrity of near shore or in-the-water structures may be impacted by dredging activities, or where modeling indicates that silt curtains will not be sufficiently effective.
- A combination of process control options will be considered where operational requirements may warrant. For example, auxiliary silt curtains and air curtains may be considered to augment sheetpile wall containment process options.
- Innovative process options will be considered in limited unique circumstances when operational controls may not be sufficient to control migration of TSS and PCBs, and when other process options are deemed inappropriate. For example, caisson dredging may be considered for isolated, small areas with high levels of PCB content or silt curtains augmented with king piles may be considered, if river bottom debris or shallow bedrock renders sheetpiles inappropriate.

6.6 Process Option Framework for Intermediate Design

The framework for the process to evaluate, select, and design resuspension control process options during the Phase 1 and Phase 2 Intermediate Design stages is presented below. As discussed earlier, completed environmental projects provide only limited information for selecting resuspension control process options. Accordingly, a more systematic process has been developed to aid in selecting and designing the resuspension control process options for the Hudson River project.

The process to select the appropriate resuspension control system includes two steps; each step involves calculating quantitative estimates of resuspension. Subsequently, the optimum resuspension control system will be selected based on the predicted ability to meet the near-field and far-field performance standards and the use of professional judgment. Given the state of knowledge on dredge resuspension and the effectiveness of resuspension control systems, Phase 1 will be an important and necessary test to determine if refinements in dredge type or control systems are necessary.

These steps of the process to evaluate, select, and design resuspension control process options are described below.

1. **Estimation of source strength:** This estimate will be developed by modeling. The main objective of this modeling is to provide estimates of sediment and PCB (i.e., particulate and dissolved) loads from the immediate vicinity of the dredge head to the near-field region downstream of the dredge. These loads will be used as input to the near-field transport model. Within the dredge zone, resuspension losses will be estimated using a version of the CSTR-Chem model developed by the USEPA (USEPA, 2002a), modified to account for differences in PCB particulate concentration among sediment types.

   The results of the Dredge Elutriate Tests (DRET) completed as part of the TS Work Plan (BBL, 2003d) will provide some insight relative to the results of this source strength modeling. However, the DRET results will be only considered as order-of-magnitude indications for PCB concentrations in the vicinity of the dredge head. As outlined in the TS Work Plan (BBL, 2003d), engineering judgment will weigh significantly in identifying resuspension controls, given the high level of uncertainty associated with source modeling.

2. **Near-field modeling:** The near-field modeling will predict the fate and transport of PCBs, in dissolved and particulate form, for the region in the immediate vicinity of the dredge head and out to an area 1 mile downstream. The sediment and PCB loads from dredging resuspension losses (established from the elutriate testing to be performed as part of the work planned under the TS Work Plan [BBL, 2003d]) will be input as upstream boundary conditions to the near-field model, which will simulate sediment and PCB transport in the near-field region.

   The GE modeling framework for the Upper Hudson River will be used to conduct the near-field simulations of the dredge plume. The GE near-field model will be used instead of the TSS-Chem model to provide improved accuracy in model predictions since the GE framework uses a two-dimensional, vertically-averaged hydrodynamic model. Using the GE model will make it possible to account for spatial variations in bathymetry and current velocity, as well as temporal changes in river flow rate.

   The near field model will include fast and slow PCB kinetics desorption components derived from the literature and checked for consistency with the elutriate tests performed in accordance with the Treatability Study Work Plan. The basic grid size is anticipated to be about 10 meters by 50 meters; however, a smaller grid size may be required near the dredge head or control structures. Simulations will be conducted for Tri+ and Total PCBs. The results will be used to evaluate the efficacy of candidate dredging methods and control options to meet the performance standards. The sensitivity of the model to uncertainties in model input and assumptions will be assessed and factored into decisions regarding resuspension controls as appropriate. The model specifications and fully functioning model (including uncompiled code) will be provided with the Intermediate Design Reports.

Modeling will be performed assuming resuspension with and without the use of resuspension control process options to assist in deciding whether resuspension control process options are necessary and which system(s) would be most appropriate. Although the modeling is quantitative, the results will have a significant uncertainty and as a result, will be a factor in a weight of evidence evaluation to select the appropriate resuspension control option. Upon the selection of the resuspension control system to serve a particular dredge area, its approximate location, layout and configuration will be developed. The location, layout, and configuration are affected by site-specific and operational considerations (e.g., proximity of navigational areas, the need to provide means of ingress/egress for vessels to the dredge area, and shoreline and underwater peculiarities of the dredge area environment), as well as vessel movements inside the dredge area, other dredge activities (e.g., spud and anchor placements), and the installation and removal of the resuspension control process options.

6.7 Interrelationship with Other Project Elements

The resuspension control project element interacts with a number of other project elements, such as dredging, dredged material transport, and backfilling/capping, as illustrated on Figure 2-2. The resuspension control element receives inputs from these elements, but also provides outputs that influence these other project elements.

The most important project element influencing the resuspension control design is dredging. The selection of dredge(s) type, dredge operational characteristics, and dredge production rate, along with the associated resuspension characteristics, influence the resuspension control design. The selection of the dredge method and its operational parameters, together with the type of sediment to be dredged, will define the turbidity generation potential or source strength at the point of dredging, providing one of the important inputs to the resuspension control project element. Other factors associated with dredging include vessel movement, spud and anchor placement, and placement and removal of the resuspension control system itself.

In addition to dredging, the resuspension control project element is affected by the dredged material transport method selected. Barge and vessel movement may affect the selection and design of the resuspension control system. Finally, the backfilling/capping project element will affect the resuspension control design if such process options are needed to remain in place during backfill/cap placement. The type and volume of material to be placed as backfill/cap, placement method and rates, and equipment selection and maneuvering requirements will affect the selection and sizing of the resuspension control system.

The output from the resuspension control project element may affect the dredging process, through prescription of needed operational controls on the dredge equipment. Resuspension control could also affect the dredged material transport project element because the final selection and specification of resuspension control process options in the river will influence navigability in the vicinity of the process options.

6.8 Summary

The following conclusions can be drawn from the analysis of the resuspension control process options:

- The no-containment, silt curtain, sheetpile wall, and other process options have been used on previous environmental dredging projects.
- Silt curtains are generally effective under a limited range of conditions (such as water depths shallower than 20 ft and relatively low to moderate velocities).
- The efficiency of resuspension control process options appears to depend a great deal on the three main factors affecting resuspension potential (dredge type, particle size of sediment, and current velocity). Past projects generally do not provide adequate information to predict system efficiencies.
- A two-step process is proposed for the Intermediate Design stage to evaluate, select, and design the resuspension control process option most suitable for the dredge areas. This process will provide information regarding source strength and near-field modeling to assist in the selection and design of the layout and configuration of the resuspension control systems. However, due to the empirical nature of this process and the associated uncertainties, this process is at best qualitative.
- Resuspension may also occur as a result of activities other than dredge operations, such as barge movement to land-based processing facilities or the installation and removal of resuspension control systems. Such activities and their impacts will be addressed during the Intermediate Design stage.

The specific resuspension control systems for Hudson River dredge areas will be selected from the preliminary list of resuspension control process options retained for further consideration during Phase 1 and Phase 2 Intermediate Design stages (see Table 6-3, below).

Table 6-3 – Summary of Resuspension Control Endpoints for Preliminary Design

Process Option	Likely Conditions of Application
No containment	• Will be considered as first engineering contingency for all dredge areas and scenarios.
Silt curtains (single or potentially multiple silt curtains may be considered)	• In areas where dredge-head and operational controls may not be sufficient or may reduce productivity to an unacceptable degree; • In areas where depths are less than 20 ft and river flow velocity is less than about 1.5 fps; and • In navigational areas.
Sheetpile walls	• In areas where dredge-head and operational controls may not be sufficient; • In areas where modeling predicts that silt curtains will be unacceptably inefficient; • In areas where river flow velocity is greater than 1.5 fps; and • In areas where the integrity of near-shore or shoreline structures is affected by dredging.
Combination of process options	• Auxiliary silt-curtains and air-curtains to be combined with sheetpile walls may be considered, where transit of vessels into and from the dredge area may be required; and • Silt curtains may be augmented with submerged portable dams in areas where river bottom conditions render the use of sheetpile walls impractical.
Other resuspension control systems	• In certain areas, where small, localized sediment is encountered with high level of PCB contamination, the use of caisson dredging may be considered; and • In areas where silt curtains may be otherwise appropriate, but river bottom conditions may not make their anchoring possible, a king-pile system may be used.

The *Phase 1* and *Phase 2 Intermediate Design Reports* will include a selection of the resuspension control process options for each removal area, including a layout and overall configuration of the process options around each dredge area.

7. Dredged Material Transport

Once material is dredged from the river, it will need to be transported to the land-based processing facility (or facilities) for processing (e.g., offloading, dewatering, solids separation, water treatment). This section focuses on the dredged material transport project element and builds on the preliminary selection of dredging equipment presented in Section 5. For this Preliminary Design, two process options are presented for transporting the dredged material to the processing facilities: 1) barging of mechanically dredged material; and 2) hydraulic transport (pipeline) of dredged material. When specific dredge equipment and production rates are further defined and the treatability studies are completed, these dredged material transport process options will be further evaluated.

Specific dredged material transport topics discussed in this section include:

- Basis of design;
- Design approach;
- Dredged material transport options;
- Transport considerations for the land-locked area of River Section 2;
- Interrelationship with other project elements; and
- Summary.

7.1 Basis of Design

Pertinent details of the basis of design for dredged material transport, including project requirements, KPVs, and design assumptions are discussed below.

7.1.1 Project Requirements

The project requirements affecting dredged material transport are, or will be, set forth in several documents prepared by the USEPA, including the ROD (USEPA, 2002a), draft Engineering Performance Standards (Malcolm Pirnie and TAMS, 2003), and draft Quality of Life Performance Standards (just recently released). These documents will affect both the dredging and dredged material equipment and project elements since the type of equipment selected for dredging will dictate the design of the dredged material transport process options (i.e., barging of material or hydraulic pipeline transport).

The draft Engineering Performance Standard for dredging productivity was used as an initial guide for sizing/selection of the transport method to the processing facility. Similar to dredging, an initial assumption regarding sizing of the project elements is needed to evaluate individual process options. For example, the quantity of sediment removed on a daily basis is needed to determine the number and size of barges, hydraulic pipelines, and hydraulic booster pumps. For Preliminary Design purposes, it has been assumed (based on the target Phase 2 production rate of 530,000 cy per year and assumptions of 5-day to 7-day per week of operation from early May through the end of October) that the average daily production rate would range from 3,000 to 4,000 cy per day. However, this assumption may change based on the results of dredge area delineation and the recently released draft Quality of Life Performance Standards, and is subject to change in the Phase 1 and Phase 2 Intermediate Design stages. During the Intermediate Design stages, transport equipment (e.g., pipelines and barges) will be sized to meet the productivity standard. Although Phase 1 will involve a lower overall volume, the productivity Performance Standard requires that for at least 30 days during Phase 1, the project must operate at the full-scale Phase 2 rate. Therefore, the Phase 2 daily production rate will be used in design for Phase 1.

Since the USEPA has not finalized the draft Engineering Performance Standards, they have only conceptually been considered for this Preliminary Design stage. Specific dredge areas and processing facility locations are also unknown at this time. These factors, as well as the draft Quality of Life Performance Standards (which have not been considered in the Preliminary Design, since they were just recently released), will be further evaluated during the Phase 1 and Phase 2 Intermediate Design stages.

7.1.2 Key Process Variables

KPVs for dredged material transport include the following:

- **Dredge type:** The dredge type selected will limit the methods of transport available for transporting the dredged material from the point of dredging to the processing facility (or facilities). For example, barge transport is limited to mechanically dredged material, whereas hydraulic pipeline transport can be used to transport sediment that has been dredged with a mechanical, hydraulic, or pneumatic dredge.
- **Equipment availability:** It is anticipated that barges, dredges, pipelines, booster pumps, and pushboats (i.e., tugboats) are generally available. However, the equipment may (of necessity) originate from outside

the Hudson River Valley; in addition, due to the magnitude of the Hudson River project and project-specific requirements, equipment may need to be fabricated to be compatible with a number of factors including water depths, final Engineering Performance Standards, and final Quality of Life Performance Standards.

- **Processing facility location:** The locations of the processing facilities, relative to dredge areas, will dictate the transport distance for barging (time and frequency), as well as the hydraulic pumping distance.
- **Processing facility size constraints:** Constraints on facility size, such as daily production rates, dredged material (front-end) staging, processed material staging area requirements, and final transportation and disposal scheduling (rail transport), will affect the dredged material transport design. Once the relevant DAD Report(s) for a given phase of dredging are approved and processing facility site(s) for that phase are selected, these key transport process variables can be further evaluated.
- **Water depth requirements:** Water depth requirements will affect/limit the type of equipment that will be used for the dredging process. Actual water depths will dictate the type of dredge used, as well as the process for transporting the dredged material. Water depths will not be known until the locations of the dredge areas are determined.
- **Proximity to navigational channel:** The proximity of removal areas to the navigational channel will affect navigation of both construction-related-, and recreational vessels in the Champlain Canal. At this time, it is unclear where the dredge areas are located in relation to the navigational channels.
- **Consistency of dredged material (percent solids):** The consistency (i.e., percent solids) of dredged material depends on the removal/excavation method. Mechanical dredging typically introduces an additional 20 - 25% water to the in-situ dredged material on a volumetric basis, while hydraulic dredging is composed of a slurry that is typically 95 to 97% water on a weight basis. In addition, it is assumed silt, clays, sand, and gravel can be transported by barge or hydraulically pumped. Larger media (cobbles, boulders) cannot be hydraulically pumped, and will need to either be left in place or be removed and transported by barge. If removal of boulders is required, they will be placed on a deck barge for ease of unloading. Additional geotechnical data on the material types located within the dredge areas will be collected during the field activities described in the SEDC Work Plan (BBL, 2003b).
- **In-river infrastructure/obstructions:** Once the dredge locations are known (after the relevant DAD Report is approved), in-river structures and debris that may interfere with the dredged material transport process will be mapped and identified (during the SEDC Program). However, it may not be possible to identify and map potential debris, including buried debris, thereby presenting a risk of clogging or breaking a hydraulic transport pipeline.

- **Failure risk:** Each dredged material transport method has an associated failure risk. When using a barge, the chance of failure would stem from the barge running aground or potential swamping due to uneven loading or leaks, or damaging down river structures in the event that the tug moving the barge along the river lost power. In addition, tugboat and barge access may be dependent on surface water elevation and clearance under bridges may only be possible during low flow, or may require lowering of the water level using the dam and lock system. Under a hydraulic transport scenario, areas of high river velocity may affect the location of pipelines due to forces that would be imparted on the pipe. Pipeline placement/routing in high-velocity areas could potentially break the pipe by repetitive movement of the pipe if it is placed within these areas. Moving the pipe in these high velocity areas also poses a safety hazard

- **Transport capacity:** The dredging method, location of the dredge area, and nature of the material (i.e. cobbles vs. silts) will influence the transport method. For mechanical dredging, material will be loaded into barges or onto flat deck barges with coaming for transport to the processing facility. Transport capacity of the barges depends on the water depths in the vicinity of the dredge area as well as operational constraints. Dredge areas in deeper water will allow deeper draft barges to be used and ultimately allow more material to be transported (thus reducing the number of trips to the processing facility).

- **In-river support:** In-river support depends on the type of equipment and size of the equipment being used and/or handled. Barges will require pushboats with sufficient horsepower (hp) to move them throughout the river (the size of the pushboat is proportional to the weight/size of the barge requiring movement). A small hydraulic dredge may require a smaller tender tug to assist with anchor placement/movement and advancement to the next dredge area. Larger, more powerful tugs (approximately 1,000 hp) will be required for barge handling/movement. The movement of hydraulic pipelines will require a tender tug and possibly a small deck-mounted crane for placing pipeline sections into the water when extending the pipeline and for lifting the pipeline sections out of the water for inspection and repair.

- **On-land support:** Support equipment for transportation will be required and will depend, to some degree, on the transport method. For example, a staging area will be required for operational support (not related to dredged material) including loading and offloading of personnel, spare parts, fuel, oil, and lubricants.

7.1.3 Design Assumptions

The following assumptions were used to develop the Preliminary Design for the dredged material transport project element:

- Transport of dredged material from the river's edge to the land-based processing facility will not occur via truck, with the possible exception of materials from within the land-locked area.
- The maximum lock length is 300 ft and the anticipated maximum tugboat boat length that will be used is approximately 75 ft (leaving approximately 25 ft inside the lock for safety). Maximum tugboat height is 17 ft (the maximum height may be increased by use of a retractable pilot house.) It is assumed no other vessels will be allowed in the lock during barge/tugboat transit.
- The maximum barge/scow width is 35 ft (navigable width of the canal locks is 43.5 ft), with a maximum barge length of 200 ft. The estimated maximum draft of a fully loaded barge is approximately 10 ft.
- As discussed previously, it is assumed that 3,000 to 4,000 cy per day of sediment (in situ) need to be transported from the dredge operations to the processing facility(ies).
- Shallow draft deck barges (i.e., 200 to 500 cy capacity range) could be modified to carry dredged material (by adding cribbing/coaming to the deck as needed) to reach shallow draft areas.
- Booster pumps (for hydraulic transport) will be located on barges or on the shoreline.
- Hydraulic pipelines may be either supported by floating pontoons or submerged on the river bottom, and/or possibly located on the shoreline. Hydraulic pipelines will have to be configured to bypass lock and dam structures.
- Locks will be staffed and operated as needed for dredged material transport and barge movement.

If these assumptions do not prove to be correct, the design will require modification.

7.2 Design Approach

Process options for dredged material transport will depend on the type of material being removed and dredge equipment selected. For example, two potential transport methods will be used for mechanically dredged material- a barge, or hydraulic pipeline. The second process option includes mechanical loading of dredged sediment into a hopper bin, which in combination with a series of high solids pumps, will hydraulically move dredged material through a pipeline to the processing facility. Process options for transporting hydraulically and possibly pneumatically dredged materials for the most part are limited to use of hydraulic pipelines. Barge transport of hydraulically dredged material is possible; however, due to the exceedingly low percentage of solids being transported, it would only be practical as a supplement to pipeline transport.

Dredged material transport options will also depend on the location of the processing facilities. It may not be possible to route pipelines to some areas of the Upper Hudson River if access to land-side properties is not available. Given that the locations for dredge areas and processing facilities are not known at this time, the approach for dredged material transport is conceptual in nature and will be consistent with the approach used for dredging, which includes identifying the range of potential transport options that are applicable to the Upper Hudson River, which in turn will be limited by the selected dredging methods, and the USEPA's evaluation of potential facility sites, which is still ongoing at this time.

7.3 Dredged Material Transport Options

The following two process options are being considered for transporting the material from the dredge area to the processing facilities:

- Barging of mechanically dredged material; and
- Hydraulic pipeline transport of hydraulically (and possibly pneumatically) dredged material and hydraulic pipeline transport of mechanically dredged material, after slurrying).

Each of these options is described in more detail below and the potential modes of transport are listed in Table 7-1, along with their characteristics and a discussion of their abilities.

7.3.1 Barging of Mechanically Dredged Material

Mechanical dredging will utilize a bucket operated by a crane or excavator fixed on the deck of a barge. As dredged material is excavated from the river bottom, it will be placed into a barge (or scow). The barge will be located alongside the dredge unit so that as the bucket digs (directly off its bow) it will swing no more than 90 degrees to place the material in the receiving barge. This receiving barge position will minimize cycle time and maximize capture of dredged material during barge loading. In some cases, the bucket may have to swing wider to accommodate restricted manageability in shallow water areas. Proper distribution of the load is critical to avoid overturning or cap sizing the barge.

For mechanical dredging, all material types can be handled with a dredge bucket. If large debris will need to be moved, larger dredge buckets and a large crane to lift the debris out of the water may be necessary.

After loading, the barges will be moved by a tugboat. The size and required power of the tugboat will depend on the size of the barge, quantity of dredged material loaded, river flow conditions, and transport distance to the processing facility. The sub-sections below summarize the barging transport equipment/scenarios, as well as the equipment required for moving the barges.

Multiple full-sized barges (each with a capacity of approximately 1,000 cy) will be required to meet the mechanical dredging demand. The number of barges will depend on the location of the processing facility including the distance between the dredge area and processing facilities, dredge production rate, the solids content of the dredged material (i.e., bulking), the upstream and downstream barge velocities, the number of locks along the transport route, the cycle time for each lock, berthing space at the processing facility, unloading time, and turnaround area on the river. Small dredged material barges will also be used as needed. It is estimated that multiple modified deck barges (each with a capacity of approximately 200 to 500 cy) will be required for dredging in shallow water areas and for handling debris removed prior to or during dredging. The extent of shallow water areas that need to be dredged is unknown at this time.

Detailed transport scenarios for dredged material and backfill material transport will be developed once the locations of the dredge areas are known, different material types are identified, and the processing facility location(s) are determined.

7.3.1.1 Barges

Deck barges and scows of varying sizes will be considered for transporting dredged material to the processing facilities. The range in barge sizes (i.e., variation in length, width/beam, and depth) will directly affect the dredged material holding capacity of the barges, and different-sized barges will be used for a range of river conditions. Smaller barges (i.e., modified deck barges with coaming added to them and a dredged material capacity of 200 to 500 cy) will be used for river areas that require a shallower draft (clearance between the barge bottom and the river bottom) or narrow sections of the river that may require a smaller barge due to maneuverability restrictions. Larger-capacity barges (e.g., 1,000-cy barges) will be used when water depths permit.

Two primary types of barges will be used to transport dredged material to the processing facilities. A hopper/scow/deck type barge will typically transport sand, silt, and gravel material, while a flat-deck barge will transport boulders, cobbles, debris and other obstructions that are removed from the river. The variation in the two types of barges relates to ease of unloading. Large boulders can be difficult to offload from a barge; however, if the boulders are loaded onto a flat-deck barge, they can be readily unloaded using a front-end loader or an “orange peel” grapple bucket.

More specific information on barging is provided below, including barge characteristics, barge loading requirements, and movement of barges/equipment. Appendix 7-A provides vendor information on the different types of material barges that may be used on this project.

Barge (Hopper/Scow/Deck Barge) Characteristics

Smaller barges (with a dredged material capacity of 200 to 500 cy) are typically built from a flat-deck barge with coaming placed along the perimeter of the barge. The coaming is usually built from steel to form a watertight wall (which prevents water from ponding in a corner of the barge and the flooded area of the barge from becoming overloaded) extending possibly 3 to 5 ft above the deck of the barge. These barges range in length from 60 to 110 ft, with the beam size varying from 30 to 35 ft. The typical draft of a fully loaded vessel ranges from 3 to 5 ft.

The larger barges offer capacities up to 1,000 cy, vary in length from 175 to 195 ft, and have a width/beam ranging from 26 to 35 ft. The typical draft of a fully loaded vessel is approximately 10 ft. Barges may need to be “light loaded” to prevent grounding in shallow water areas.

Table 7-1 includes a generalized description of the different types of barges that may be used for the project and Appendix 7-A provides a summary of different types of dredged material barges that may be used on this project.

Barge Loading Requirements

Careful loading of the barges is critical and dredged materials need to be evenly loaded so that the barge will have equal draft at the four corners. Improper loading will potentially cause one area of the vessel to sit lower in the water causing the barge to swamp (i.e., take on water and sink). In addition, river conditions will dictate where the barge is filled (i.e., near the shore, or in deeper water near the navigational channel). Therefore, larger barges will need to be located close to the channel’s edge to accommodate their draft when fully loaded. Dredge areas in shallower water may require smaller barges with a shallower draft. Lastly, another loading/transport option includes partially filling the barge in shallow water and then moving the barge to deeper water where dredging is taking place (i.e., in an area such as the navigation channel).

These transport options will be designed during the Phase 1 and Phase 2 Intermediate Design stages and barges will be selected based on the reach of the dredging equipment (i.e., barge-mounted excavator will have to be able to reach over the coaming on an empty hopper barge to fill it).

Movement of Barges/Equipment

The limiting factor on how the barges are handled on the river (and what size can be used) will be the lock width restrictions. Barges will most likely be pushed from the stern for river travel and transport through the canal lock system. The navigable limitations of the locks are published as 43.5 ft wide and 300 ft long (NYS Canal Corporation, 2003). The operational width of the lock restricts barges from being moved/transported "on the hip" and possibly restricts other boats from entering the lock (due to safety concerns, as well as space limitations).

During barge maneuvering within the river it is possible that the barge will be guided "on the hip" of the tugboat for ease of placement alongside another vessel/barge or for anchoring purposes. It is also possible the barge would be pushed in a perpendicular manner (forming a "T" between the barge and the tugboat) into a shallow shoreline area where the tugboat may require the extra under keel clearance and will benefit by having the propeller further into the channel.

When moving barges, it is important to consider the potential for the barge to run aground in shallow-water areas, which could damage the hull of the barge and result in the barge taking on water and possibly capsizing. Another potential concern is the loss of power, which could cause the barge to drift freely with the wind and river currents, potentially resulting in the barge or the support tugboat floating into a structure, running aground, becoming pinned or going over a dam.

Canal/Lock Schedule

As stated in the ROD Responsiveness Summary (ID 337804), "the locks are operated on an as-needed basis during regular hours of operation, which are from 7 am until 10:30 pm. However, with advance notice, commercial users may pass through the locks 24 hours per day" (USEPA, 2002a). According to NYS Canal Corporation records, the closing time for the canal system during 2003 was 10 pm. The standard lock closing time also varies throughout the year. During the first 2 weeks and last 4 weeks of each season the standard closing time is 5:00 pm. A minimum 24-hour advance notice is required to allow for off-hour lock passage and the notice must be made to Lock 12. Passage time through a lock (a "lockage") is described as varying from 24 to 30 minutes. Currently, the only prohibited materials under the Canal Rules and Regulations are explosives.

The actual schedule of lock operation in the Champlain Canal for the 7-year period from 1997 to 2003 is provided in Table 7-2, below:

Table 7-2 – Summary Schedule of Champlain Canal Lock Operation

Year	Locks Opened	Locks Closed	Weeks
2003	May 5	Nov. 2	26
2002	May 6	Nov. 3	26
2001	May 7	Nov. 4	26
2000	May 1	Nov. 19	29
1999	May 3	Nov. 21	29
1998	May 4	Nov. 22	29
1997	May 5	Nov. 23	29

Notes:
1. Reference: NYS Canal Corporation, 2003.

7.3.1.2 Tugboats

Barges are typically maneuvered using a tugboat. Tugboats are often reserved/classified for moving large cargo vessels found at ports such as the Port of Albany or Port of New York/New Jersey. Tugboats can be as long as 120 ft, which is too long for the lock system when pushing a 200-ft barge, while others may be too tall to pass under the bridges along the Champlain Canal system. Some tugboats; however, have the hydraulic capability to raise and lower the pilot house as needed to pass under overhead obstacles. If material/barges end up being moved beyond the canal/lock system into the Great Lakes or south toward New York City, these larger vessels will be considered. The remainder of this sub-section focuses on the characteristics of the tugboats typically found in an inland river environment.

Characteristics of a Tugboat

Typical tugboats can vary in length from 25 to 75 ft, have a width/beam ranging from 10 to 26 ft, and have horsepower ranging from 170 to 1,300 hp. Typical water depths required for these vessels range from 3 to 9 ft. The power from the engine is typically transferred to a drive shaft that turns one of three different types of propellers:

- Standard shaft to propeller connection;

- Duct (kort nozzle); and
- Propeller tunnel.

The first (standard shaft to propeller connection) is the most common type of propeller, but reduces the overall draft of the vessel by the amount the propeller extends below the hull of the vessel. The second (kort nozzle) is a circular structural shroud surrounding the propeller (Benford, 1991). When designed properly, such a nozzle increases the thrust of the propeller and protects the propeller from damage if an underwater object is encountered. The third type (propeller tunnel) is formed when the bottom of the vessel is “scooped out” so a larger, more efficient propeller can be fitted to a shallow draft vessel, which is common in river tugboats (Benford, 1991). Various propulsion process options are being considered in the Phase 1 and Phase 2 Intermediate Design stages as propeller wash may be a significant source of sediment resuspension.

Table 7-1 includes a range of tugboat dimensions (i.e., a range of length, width, beam, and draft) that may be used for the Hudson River project, and Appendix 7-A provides vendor information related to different tugboats.

7.3.2 Hydraulic Transport of Dredged Material

Hydraulic transport (i.e., pipeline) can be used with hydraulic, mechanical, or pneumatic dredges. The dredged material is pumped by the dredge or an auxiliary pump through a pipeline to the processing facility. The hydraulic pipeline that conveys a water-sediment slurry can be constructed from either a steel pipe or plastic pipe, often referred to as high-density polyethylene (HDPE) pipe (discussed in more detail below). Hydraulic transport of dredged material typically conveys silts, clays, and sands slurries. Larger size cobbles/stones are typically handled with a clamshell bucket (i.e., mechanical dredging).

Hydraulic dredges are installed with engines that provide suction of material from the river bottom into a transport pipeline. The horsepower directly corresponds to the potential transport distance (factoring in dredged material type being pumped). For a typical 12-inch cutter suction dredge, 3,000- to 5,000-ft pumping distances can be achieved, depending on the dredged material being transported (i.e., silt, sand, clay, or gravel) (Ellicott, 2003) and the vertical head difference between the dredge and discharge locations. For the project, the pipe size (diameter) will most likely range between 12 and 16 inches, the pipe size sets the dredge size) and will theoretically be able to pump distances from 3,000 to 10,000 ft (Ellicott, 2003). Additional slurry transport distances can be achieved using booster pumps. Booster pumps are placed along the pipeline to provide sufficient transport velocity in the pipeline system. The booster pump adds more horsepower to the system allowing the slurry mixture to be conveyed farther. Table 7-1 provides a generalized description of hydraulic pipeline.

Steel Transport Pipe

Transport of dredged material via carbon steel pipe offers advantages and disadvantages. Carbon steel is durable from the aspect of internal and external wear and tear. However, it can be difficult to move, can rust, and can be difficult to repair. Pipe connections can be mechanical-type locking connections, sealed welds, or bolted flanges. Individual pipe lengths vary, but typical lengths range from 50 to 100 ft. The pipe diameter varies in size from 8 inches to a typical maximum of 36 inches (larger sizes are available). For the Hudson River project, the pipe diameter will most likely range between 12 and 16 inches. This diameter range is based on the potential output range (slurry cy per hour) of the hydraulic dredges that may be used. If a floating pipe is used, it would be supported on the water's surface by pontoons. The pipeline may also be submerged to avoid interference with vessel movement. However, this limits access to the pipeline for repairs, and increases difficulty of leak detection.

Field support equipment that may be required for maintenance/movement of the steel pipe includes mobile welding equipment, a small deck-mounted crane for lifting the pipe out of the water for repair and movement, and a front-end loader with grapples for lifting the pipe and for movement along the shoreline.

HDPE Pipe

As with steel transport pipe, using HDPE pipe has its advantages and disadvantages. The plastic is more flexible (in long lengths), light weight, and resistant to corrosion. However, long lengths can be difficult to move, and HDPE pipes can be difficult to repair. HDPE pipe connections are typically made by a heat fusion devise (heating the ends of the pipe and pushing them together to form a structurally sound water tight seal) or by the use of bolted flanges. Individual pipe lengths vary, but typical lengths range from 50 to 100 ft, with 100 ft being the most economical. Pipe lengths can be readily cut in the field. The diameter of HDPE pipe varies in size from 8 inches to a typical maximum of 36 inches. For the Hudson River project, the pipe diameter will most likely range between 12 and 16 inches. If HDPE pipe is to be submerged in the river, it will require anchoring.

Double-Walled Pipe

Use of double-walled HDPE pipe will require the main transport line to be "fed" through a larger diameter line for protection should line failure occur. Special flanges and gaskets will have to be used at booster pumps to accommodate the two different pipe diameters. The use of double-walled pipe on dredging projects is not typical. Two projects where it has been used include the Grand Calumet River project in Gary, Indiana and the St. Clair River project in Sarnia, Ontario.

Maintenance/movement and service of a double-walled pipe could pose a significant logistical challenge and slow the dredge production. At a minimum, field support equipment that may be required for maintenance/movement of double-walled HDPE pipe includes mobile fusing equipment, a small deck-mounted crane for lifting the pipe into the water for placement and out of the water for repair and movement, and a front-end loader with grapples for lifting the pipe for movement along the shoreline. However, if a rupture were to occur on the interior pipe, finding the leak would be challenging and would require stopping the project to dismantle potentially hundreds of feet of pipe to locate and repair the damaged section. Both pipes would potentially have to be cut or "de-threaded" for service. While transducer could be used to assist in locating blockages and leaks in the pipe, this would not eliminate the need to stop the entire dredge operation to find the location of the problem and the need to open both pipelines to implement the repair. Also, double-walled pipe has not been used for long pumping distances. For the Hudson River project, there is a potential need for dredged material to be pumped nearly 60,000 ft to the processing facility (as identified in the FS [USEPA, 2000]). Pumping material further distances than this would require excessively long startup times (time to get water flowing through the system completely) and long times to flush the pipe out prior to shutting down or moving the dredge.

If the pipelines (both steel and HDPE) are not rotated/replaced on a yearly basis, grooves can be worn in the pipe, potently causing failure/leakage of the pipe. Another potential concern during dredging is blockage-related failures (e.g., associated with debris that could cause clogging within the pipeline).

7.3.2.1 Booster Pumps

Booster pumps are primarily used for increasing the pumping distance between the dredge and the unloading point (in this case, the processing facility). The pumps are strategically located to provide increased pumping head when the head friction loss cannot be overcome. Booster pumps range in discharge size from 10 inches to a typical maximum of 30 inches, with total installed horsepower for these pumps ranging from 175 to 6,000 hp, respectively. For this project, booster pumps will match the dredge selected and are expected to range in discharge size from 12 to 16 inches. The booster pumps will potentially have a pumping range of 3,000 to 10,000 ft (i.e., increasing the linear pumping distance from 0.75 to 2 miles for each pump used). Pumping distances will vary for the dredged material types mentioned above due to the variation of the slurry specific gravity. Slurry concentrations typically range from 3 to 5% solids depending on the dredged material type and depth of cut. The low percentage of solids is often the result of the extreme caution exercised during environmental dredging to minimize the resuspension of sediment into the water column and control the depth of cut. The dredge typically makes more controlled dredge cuts to minimize removal of excess sediment and moves at slower speeds to minimize resuspension resulting in more water added into the slurry mixture.

Booster pumps and fuel storage tanks are typically located on skid-mounted rigs that can be lifted onto a deck barge. Some dredging companies have dedicated booster pump barges. Either approach will allow access to the engine/system for refueling (typically daily) and for servicing, as well as ease of transport and movement once on the water. Booster pumps may also be located on the shore, which would require access from the property owner.

Table 7-1 provides a generalized description of a booster pumps and Appendix 7-A provides vendor information on different types of booster pumps that may be used for the Hudson River project.

7.3.2.2 Positive Displacement Pumps

Positive displacement pumps can be used with mechanical dredging with the dredged material placed into a hopper on the deck of the barge. Dredged material is then pumped to the final destination through steel or HDPE pipeline. The hopper can be equipped with a debris screener and sediment homogenizer. Water and other additives may be added to facilitate transport. A positive displacement pump is similar in operation to a concrete pump, except sediment is pumped at higher pressures than conventional hydraulic transport methods and requires less water for movement. Another loading scenario would be to mechanically dredge the material and use a positive displacement pump to load a nearby barge.

One example of a dredging project using the positive displacement pump is the demonstration project on the Upper Peoria Lake in Illinois where dredged materials were pumped a few hundred feet through a steel discharge pipe. Booster pumps could be added, as needed, to increase the transport distance. However, booster pumps have not been used and/or tested with this potential process option.

Table 7-1 provides a generalized description of two positive displacement pump systems. The first is a pump system typically used to transport concrete through a pipeline. The second system was used to transport mechanically dredged material at the New Bedford Harbor (Foster Wheeler, 2001). This system included screening of the dredged material to remove debris, slurrying of the material to facilitate pipeline transport for 3,000 ft to processing/disposal (i.e., confined disposal facility, or CDF). Both of these systems would require the use of booster pumps if the dredged material is pumped several thousand feet. Table 7-1 also lists equipment for hydraulic unloading that could be used to transfer sediment from barges to the sediment processing facility. This application is limited to shoreline operation and will be considered if size separation is retained as a sub-process option within the sediment and water processing project element during the Phase 1 and Phase 2 Intermediate Design stages.

The remainder of this sub-section provides more specific details on pipelines used for the hydraulic transport of dredged material.

7.4 Transport Considerations for the Land-Locked Area of River Section 2

The portion of river located between Fort Miller Dam (RM 186.2) and the Thompson Island Dam (RM 188.5) poses a logistical challenge as this section of the river is bound by the above-mentioned dams and is bypassed by the navigational channel. Moving equipment into this land-locked area and transporting dredged material and equipment out can be accomplished as follows:

- Hydraulic transport of dredged material by pipeline directly to a processing facility or to barges for transport to a processing facility;
- Transport of mechanically dredged material by conveyor or truck to barges for subsequent transport to the processing facility; and
- Transport of mechanically dredged material to a processing facility by truck.

Hydraulically dredged material could be pumped to the north or to the south depending on the location of the processing facility. However, land access for the pipeline could be a significant obstacle. Also, debris will be generated and this material cannot be hydraulically transported. Moving the dredged material to the processing facility by truck would require maneuvering a barge into the river to transport the dredged material to shore for re-loading into a truck. Not only is the dredged material transport out of the land-locked area difficult, but getting equipment and personnel into the area also poses a challenge. This option would require obtaining access to a staging area along the shoreline within the land-locked area.

Under these process options, the following pieces of equipment may have to be trucked in, assembled on site, and loaded into the water:

- Portable hydraulic or mechanical dredge;
- Pipeline for dredged material transport;
- Tugboats for handling pipelines, dredge, barges, etc.;
- Barges (e.g., modular flexi-floats as noted in Appendix 7-A);
- Crane/excavator-mounted dredges; and
- Small hopper barges for dredged material transport.

The unique aspects of the land-locked area of the river will be considered further during the Intermediate Design stage when dredge areas are delineated for this area of the river.

7.5 Interrelationship with Other Project Elements

The inputs and outputs of the dredged material transport project element are illustrated on Figure 2-2. The equipment selected during development of the dredging project element and resulting production rate will feed into the dredged material transport project element. For known pieces of equipment and production rates, dredged material transport methods can be evaluated. Dredged material transport options will also depend on the location and layout of the processing facility. For example, hydraulic dredging will only be practical within reasonable pumping distances of the processing facilities (even with the use of booster pumps). In addition, other outputs clearly influence the inputs to this process. These outputs include: 1) dredged material concentration and volume of material removed during the dredging process; and 2) the front-end equalization capacity at the processing facility and any processing facility limitations (e.g., restrictions on characteristics). Therefore, any change in the dredging process or sediment and water processing can greatly influence the dredged material transport process, with the converse true as well.

The outputs from the dredged material transport process directly influence the input to the sediment and water processing task since the latter depends on the volume of dredged material transported to the processing facilities, the dredged material transport method(s), the dredged material transport rate, and the solids concentration of the slurry. Selection of the dredged material transport method(s) also influences (although to a lesser extent) the dredging and resuspension control project elements. Therefore, impacts to one of these project elements greatly influence the performance of the other project elements (dredging, dredged material transport, and resuspension control), and consequently, the overall project.

7.6 Summary

The selection of dredging equipment will drive the design for dredged material transport. It is anticipated the two primary means of dredged material transport will be barging or hydraulic (slurry) transport by pipeline. The transport method will also depend on the final locations of the processing facilities.

At this stage, it is envisioned that large debris and boulders that are removed will be loaded onto a deck barge for transport and disposal characterization. Alternatively, boulders may be left in place and worked around. Table 7-3 (below) summarizes the preliminary dredge methods with the corresponding dredged material transport method (based on dredged material type).

Table 7-3 – Summary of Dredged Material Transport Endpoints for Preliminary Design

Dredge Method	Dredged Material Transport Method
Mechanical Dredging	Barging of dredged material directly to the processing facility following excavation/dredging (for all dredged material types).
	Hydraulic transport to the processing facility via positive displacement pumps (for silts, sands, clays) after slurrying.
	Hydraulic transport (via positive displacement pumps) to a barge for transport to the processing facility (for silts, sands, clays).
Hydraulic and Pneumatic Dredging -	Hydraulic transport to the processing facility (for silts, sands, clays) augmented by booster pumps.
	Barging of dredged material to processing facility (limited to unique applications).

In the Phase 1 and Phase 2 Intermediate Design stages, specific dredge locations will be known, as will the final locations of the processing facilities. It will then be possible to select types of dredges for each dredge area, which will dictate the type of available transport method. At that time, barge types, capacity, dimensions, and the number of barges will be determined (for mechanical dredging). If hydraulic dredging is implemented, the number and size of pipelines will be selected, and the location and layout of the pipeline (including booster pump locations) will be identified.

8. Sediment and Water Processing

After sediment is dredged from the river, the dredged material will be transported from the river-based operations to the land-based processing facilities for dredged material processing. At the processing facilities, the dredged material will be separated into a water component, which will be treated to meet discharge requirements, and a solids component(s), which will be conditioned for beneficial use and/or disposal in appropriately permitted landfill(s). The conditioning may include size separation, dewatering, and/or solidification/stabilization.

This section provides an overview of the technical approach for designing the processing facilities, including design objectives, components, and process options. An effective design for the sediment and water processing project element will include consideration of process operations, backup or redundant components, and equalization features (such as storage), which would allow the continuation of river-related operations for limited periods in the event other portions of the processing system are non-operational. The design must interface with the rail car loading and transport facilities and on-river dredging, barging, and, possibly, on-river processing facilities.

At this time, the final locations of the processing facilities are unknown. The USEPA will identify and select the locations for the processing facilities from the currently identified FCSs and will release the final locations prior to completion of the Phase 1 and Phase 2 Intermediate Design stages. As such, this Preliminary Design contains conceptual information for the design of the processing facilities, including the following topics:

- Basis of design;
- Design approach;
- Process and equipment options;
- Equipment selection;
- Interrelationship with other design elements; and
- Summary.

8.1 Basis of Design

The key design considerations for the sediment and water processing element are presented below, including design requirements, KPVs, and design assumptions.

8.1.1 Design Requirements

The USEPA's Engineering Performance Standards (Malcolm Pirnie and TAMS, 2003) and Quality of Life Performance Standards (just recently released) represent key requirements for the design of the sediment and water processing project element. The productivity standard affects the rate of dredging and, therefore, the basic loadings of solids and water to be processed. The Quality of Life Performance Standards for air quality, odor, noise, and lighting may require certain design features to mitigate impacts from the processing facilities. The NYS water quality certification will likely establish limits for discharge of specific chemicals from the processing facility.

This Preliminary Design is based on processing dredged material removed from the river at the anticipated productivity rates specified in the draft Engineering Performance Standards. As described previously, the assumed daily production rate for this Preliminary Design is 3,000 to 4,000 cy per day (in-situ sediment) (based on 7-day and 5-day per week operation, respectively).

The processing facilities must be able to handle dredged material inputs (including both in-situ sediment and water from either mechanical or hydraulic dredging, or both). The processing facilities are expected to perform consistently, while receiving varying in situ sediment physical composition, ranging from non-cohesive silt/sand/gravel sediments to cohesive clays and oily fine sediments.

The processing facilities must also be capable of responding to reasonably anticipated dredging variabilities, such as the rate at which material is delivered and dredged material composition. Similarly, the processing facilities must be capable of responding to expected off-site transport variabilities, such as availability of transport vehicles, landfill receipt rates, or changes in landfill destinations. Experience from other environmental dredging projects has indicated that the proper design and operation of processing facilities is critical to maintaining dredging productivity.

The processing facility design is intended to separate sediment solids from dredge carriage water. Chemicals which need to be considered include PCBs and possibly other constituents which may be co-located with PCBs in sediment. These constituents may partition into the water phase during dredging, dredged material transport, and processing. However, the degree of partitioning between aqueous and nonaqueous phases depends on the substance and other conditions within the processing system. At this time, the constituents (other than PCBs) and concentration limits to be regulated in the aqueous discharge have not been defined by the NYSDEC. It is expected that these requirements will be specified in the NYSDEC Water Quality Certification Requirements. Once the discharge requirements are known, the conceptual design may need to be modified to address the regulated constituents and associated concentration limits.

8.1.2 Key Process Variables

Many KPVs affect design decisions and expected performance for the processing facilities. Key variables are listed in Table 8-1, along with their estimated impact on facility components, rated high, moderate, or low. KPVs include physical and chemical characteristics of sediment (both in situ and as delivered), dredging and transport methods, disposal requirements, and processing facility location, as summarized below:

- **In-situ sediment composition:** In-situ variables include sediment water contents, particle size distributions, solids density, organic content, and chemical concentrations (PCBs and other constituents). Processing facilities must be designed to handle a range of dredged material characteristics.
- **Dredge types, dredging rates, cut depths, and dredged material transport methods:** These variables affect the rates and characteristics of sediment and water to be delivered to the processing facilities. In particular, the choice of hydraulic transport allows the separation of the coarse fraction (potential beneficial use), but also significantly increases the amount of water to be treated, compared with mechanical dredging and transport. The choice of mechanical dredges affects the waterfront needs to accommodate barge unloading. Unloading and processing facilities must be sized to handle the range of hydraulic and solids loadings anticipated.
- **Dredged sediment characteristics:** This variable includes physical and chemical characteristics of the materials "as delivered" to the processing characteristics facilities. The variability will be critical to estimating hydraulic and solids loading, thus affecting equipment size. This variable will be a function of the two variables discussed above.
- **Disposal requirements:** Landfill limitations may affect the amount of solidification matrix or degree of dewatering required for the processed sediments. Materials may be separated and managed for disposal as Toxic Substances Control Act (TSCA), non-TSCA, or designated for beneficial use. Alternatively, a

monofill (single disposal facility) could receive all processed sediment regardless of chemical concentration, thus, modifying the objective regarding sediment segregation and staging operations.

- **Processing facility location:** The final locations for the processing facilities are currently unknown and as such, will be a variable until the USEPA selects the location(s) for the facility. The locations of the FCSs are shown on Figure 4-1, while a description of these sites is provided in sub-section 4.6.1.
- **Effluent limitations:** This variable affects the design of water treatment facilities. Once specified, these limits will become a design requirement.
- **Transportation uncertainties:** The uncertainty in the reliability of rail service for transport of processed material to disposal facilities will affect the design of stockpiling/staging facilities for processed material.

8.1.3 Design Assumptions

The following assumptions were used for developing the Preliminary Design for sediment and water processing: The design reflects the range of flows and equipment sizes for a 5-day per week (4,000 in-situ cy per day) and 7-day per week (3,000 in-situ cy per day) operations for both mechanical and hydraulic dredging.

- Processing facilities will be designed to handle dredged materials from either hydraulic or mechanical dredging, or both.
- Average daily dredging rates range from 3,000 to 4,000 cy per day (in-situ volumes) for 7-day and 5-day per week operations, respectively. The rate of processing must equal or exceed the rate of dredging.
- Storage facilities are assumed for incoming dredged material (1 or 2 days), treated effluent (1 day), and outgoing processed sediment (3 days). These assumptions are presented for illustrative purposes in this Preliminary Design. These assumptions will be further developed during the Phase 1 and Phase 2 Intermediate Design stages.
- For hydraulic dredging, a slurry solids content of 5% by weight at a nominal loading rate of 12 to 18 million gallons per day (mgd) is assumed.
- For mechanical dredging, it is assumed that water entrainment of 20% (by volume) will produce a slurry volume of 3,600 to 5,000 cy.
- Processing facilities will be capable of responding to reasonable dredging and sediment composition variabilities.

- Processing facilities will be capable of interacting with reasonable rail loading and transport variabilities.
- Dredged material storage capabilities for one or two days will be adequate to keep pace with dredging and transport.
- Processed sediments will meet landfill or beneficial use requirements for PCB concentration and physical characteristics (e.g., Paint Filter Test for free liquids).
- Sediment will be segregated for disposal (i.e., processed sediments with PCB concentrations above 50 mg/kg will be segregated for transport to a TSCA-regulated landfill(s), and the remainder of the material will be disposed in a non-TSCA (Subtitle D) landfill(s) or beneficially used.).
- The unit operations given in the process flow diagrams (Figures 8-1 through 8-4), which are designed for the removal of PCBs and TSS to concentrations achievable with multi-media filtration (MMF) followed by granular-activated carbon (GAC), will be sufficient to meet the substantive discharge requirements of the Federal Water Pollution Control Act (FWPCA) and the NYSDEC State Pollutant Discharge Elimination System (SPDES) (see Section 13). It is assumed that treatment is needed only for PCBs.
- Since final locations for the processing facilities have not been selected, it is assumed that adequate space will be available for the processing facility design, including space for administrative offices and parking areas; waterfront access, wharves, berthing, and loading/unloading areas; and staging areas for processed material, backfill/cap material, and habitat restoration materials.
- Sediment volume and composition data (percent solids, density, and contaminant concentrations) from the USEPA's 2000 FS were used in this Preliminary Design. A conversion factor of 1.5 to 1.6 tons of processed material per in-situ cy has been applied. This results in a nominal range of production rates from 4,500 to 6,500 tons per day of processed material output.

It should be noted that, as additional information becomes available (e.g., from the ongoing SSAP, SEDC, and treatability study activities) and as the design progresses, these assumptions may change.

8.2 Design Approach

The design of the processing facilities must be consistent with the approach expressed in the ROD (USEPA, 2002a), which requires that dredged materials (to the extent they cannot be beneficially used) be transported by rail or barge for off-site landfill disposal. To maintain control over transportation and disposal costs, dredged material must be dewatered to the degree economically feasible and within the requirements of the receiving landfill(s). In addition, the PCB concentration in the separated water stream must be controlled consistent with discharge limitations.

To achieve these objectives, the processing facilities are structured into the following components:

- Dredged material processing;
- Water treatment; and
- Solidification/stabilization.

Facilities in each of these categories are discussed below, followed by a presentation of process and equipment options that were considered and/or may be considered further as additional data become available.

A principal uncertainty is the location(s) of the processing facilities. A specific location may present difficulties with respect to river access for offloading, staging, and dockage. Other difficulties may be related to geotechnical support/stability, availability of utilities, and available acreage to house all required components. With respect to rail access, two main scenarios are contemplated:

1) Processing facilities will be located adjacent to the rail yard, with loading of processed material to rail at the processing facility, and
2) Processing facilities and the rail yard will be located on geographically separate sites, with processed material loaded onto barges for interim transport to a separate site for offloading and reloading to rail. Relative to processing facility design, this scenario would also apply if sediments are transported via barge to disposal facilities.

As discussed in Section 4, the FCSs being evaluated by the USEPA are listed in Table 8-2, below.

Table 8-2 – Final Candidate Sites Being Evaluated by USEPA

Site	Location	RM
Energy Park/Longe/NYS Canal Corporation	Ft. Edward, Washington County	Mile 195.1
Old Moreau Dredge Spoils Area/NYS Canal Corporation	Moreau, Saratoga County	Mile 193.8
Georgia Pacific/NYS Canal Corporation	Greenwich, Washington County	Mile 183.2
Bruno/Brickyard Associates/Alonzo	Schaghticoke, Rensselaer County	Mile 166.5
NYS Canal Corporation/Allco/Leyerle	Halfmoon, Saratoga County	Mile 162.4
State of New York/First Rensselaer/Marine Management	City of Rensselaer, Rensselaer County	Mile 146.7
OG Real Estate	Bethlehem, Albany County	Mile 142.8

8.2.1 Dredged Material Processing

This sub-section describes dredged material processing of both mechanically and hydraulically dredged material, including the following processes:

- Dredged material offloading from river;
- Debris management;
- Land-based transport of dredged material (e.g., piping, conveyors, trucks);
- Separations equipment (e.g., screening, trommels, hydrocyclones);
- Solids filtration (e.g., belt presses, plate and frame presses, centrifuge); and
- Solids staging for transport.

Since SEDC and DAD efforts are not yet complete, decisions on dredging equipment options are still being analyzed and both mechanical and hydraulic dredges are being considered. As such, solids management for either or both of the dredging options is discussed below. Also, a TS Work Plan (BBL, 2003d) has been submitted prior to this *Preliminary Design Report*. Results from the treatability studies will be used during the next phase of design to guide the sediment and water processing elements (i.e., the *Phase 1 and Phase 2 Intermediate Design Reports*).

Each scenario assumes an average daily dredging productivity of 3,000 to 4,000 cy per day (in-situ sediment). If dredging is performed exclusively by hydraulic dredges, and a slurry solids content of 5% (w/w) is achieved, a slurry volume of 12 to18 mgd would be offloaded. The hydraulic dredge slurry might discharge through bar screens to receiver tanks which serve as pump stations. Pumps may then transfer the slurry to processing equipment for coarse particle size separation (e.g., screening, hydrocyclones) or directly to the equalization basins.

If dredging is performed exclusively by mechanical dredges, and water is introduced into the dredge buckets at a rate of 20% (by volume), a volume of 3,600 to 5,000 cy might be offloaded via clamshell, backhoe or mud pump. Mechanically dredged material would be transferred to solidification/stabilization facilities (see sub-section 8.2.3). The remainder of this sub-section applies to hydraulically transported slurry.

A third dredging scenario is mechanical dredging with on-river slurry mix and hydraulic transport to the land-based processing facilities. A key feature of this alternative is that slurry carriage water could be partially treated for removal of the majority of particulates and then pumped back to the dredge to be slurried again with more mechanically dredged materials. Advantages of this scenario would include reduction of barge traffic, allowing coarse-particle size separation of hydraulically dredged material. It is assumed that a slurry solids density of 25% (w/w) would be achieved and a slurry volume of 2.2 to 3.1 mgd would be offloaded.

Debris removal is similar under all dredging scenarios, with debris loaded on barges for removal from the dredge area. Land-based processing facilities are required for offloading of debris, which is assumed to contain PCB residuals. It is assumed that woody debris cannot be decontaminated and will be chipped and disposed of in a commercially permitted landfill. The design will assess the viability of power washing cobbles and boulders (and perhaps larger logs) to allow their return to the river bottom, if consistent with the habitat replacement and reconstruction design

Hydraulically transported sediments might be pumped from receiver tanks directly to several banks of particle size or density separators (e.g. screens and/or hydrocyclones). The coarse solids could be staged for sampling, then loaded for transport to appropriate disposal locations (which could include beneficial use). Alternatively, the size classifier can discharge directly into trucks; however, this would not provide the solids an opportunity to drain via gravity prior to loading. The use of size separators would be contingent on results of treatability studies and the acceptability of such materials for beneficial use.

The fine particulate slurry will require additional processing and will be discharged to dewatering system feed tanks, where it will be chemically flocculated and then pumped to the dewatering system.

The fine particulate slurry might be transferred to equalization basins, and maintaining this slurry in suspension would be important to reduce downtime for tank cleanout. Alternatively, this front end storage facility could be operated as a thickener, with overflow fed to dewatering while dredged material is being received. Thickener underflow will be removed for feed to dewatering.

Plate and frame filter presses are the most likely candidates for the dewatering system. They have been successfully used at environmental dredging projects and full-scale dredging deployments. Pilot treatability studies are planned to better quantify sizing and performance data. However, other dewatering options (e.g., belt presses and centrifuges) are still being considered.

Dewatered sediments will typically be transported by conveyor systems. Where appropriate, these conveyors will be outfitted with secondary catchment for spillage, especially in areas with traffic. Trucks and front-end loaders may also be used to transport sediments within staging areas. As further discussed in Section 9, final load out to rail or barge could be accomplished with earthmoving equipment, conveyors, or hopper loaders.

The dewatered sediments will be staged within various areas – namely, areas where sediments are likely to be subject to TSCA (> 50 mg/kg PCBs), areas where the sediments are likely to be not subject to TSCA (< 50 mg/kg PCBs), and areas where it is uncertain whether the sediments are subject to TSCA. The staged materials will be sampled and analyzed for PCB content prior to transport for disposal. This multiple stream processing, staging, and testing will be avoided if a single disposal facility is utilized (see also sub-section 10.3).

8.2.2 Water Treatment

This sub-section discusses the treatment aspects for carriage water and other site runoff. Within the processing facilities, the term “water treatment” is applied only to waters after they are separated from sediment by dewatering processes. The current design concepts assume water treatment for solids and PCBs only; treatment requirements for other constituents cannot be determined until the NYS Water Quality Certificate requirements are provided.

8.2.2.1 Treatment of Dredge Water

Waters separated as a result of dewatering processes are assumed to contain suspended solids and PCB concentrations that would require further treatment prior to discharge. In NYS, water discharges need to be permitted under SPDES. For Superfund sites, permits are not required, but the substantive requirements of the permit program must be met (see Section 13). The USEPA's ROD Responsiveness Summary has concluded: "Using conservative calculations it has been determined that water column increases of conventional and trace pollutants will not contravene NYS water quality standards. It is concluded that, overall, work on the selected remedy will not significantly impact either the Hudson River's surface water resources or adjacent groundwater resources" (from Abstract in ROD White Paper 312851, *Potential Impacts to Water Resources*) (USEPA, 2002a).

Although specific discharge limits have not been established, it is tentatively assumed that the following water treatment operations would provide adequate control for solids and PCBs: chemical flocculation, gravity separation, MMF, and carbon adsorption.

Chemical precipitation/flocculation and sedimentation facilities may be required before final polishing. This initial water treatment step might first combine a number of water sources, including barge pump outs (from mechanical dredging), thickener overflows, filter press filtrate, site stormwaters from treatment and rail loading areas, and decontamination washwaters. Quantities from each of these sources will be estimated during subsequent design stages. Treatability studies will evaluate polymer treatment for particulate conditioning.

Supernatant from sedimentation facilities will be treated by MMF. Treatability studies will be performed to demonstrate the removals and effluent quality that can be expected following MMF at typical design loading conditions. Hydraulic loading rates of 2 to 10 gallons per minute (gpm) per ft^2 are being considered. MMFs use media of different sizes and densities so that after hydraulic classification (backwashing) the coarser media is deposited above the finer media. Solids removal therefore occurs deeper in the bed, rather than the top surface, as in single-medium filters. A common configuration is the dual-media filter with anthracite above sand.

Most of the PCBs in the water will be removed along with solids in the sedimentation and filtration operations. However, carbon adsorption is likely required to achieve expected effluent discharge criteria. Carbon adsorption treatability tests will estimate removal efficiency and effluent quality that can be expected following carbon adsorption, at typical design loading conditions. Design loadings in the range of 20 to 40 minutes empty-bed contact time (EBCT) are common for PCB removal. Carbon adsorption testing during the treatability testing program will assist in estimating carbon consumption rates.

Disinfection with sodium hypochlorite or other oxidizing agents may be necessary, particularly if particulates from domestic wastewater treatment facilities discharges are co-located in sediments to be dredged. Potential needs and mitigation measures will be evaluated during Phase 1 and Phase 2 Intermediate Design stages.

8.2.2.2 Site Runoff Control

Some site runoff at the processing facility might require control. Stormwater discharges associated with industrial and construction activities are subject to regulation under the SPDES program for stormwater discharges. As discussed in Section 13, no permits will be required for activities conducted "on site," but the substantive requirements of these regulations must be met. These requirements would likely be limited to implementation of best management practices and physical controls (e.g., covering chemical storage and management areas) to minimize the contact of storm water with pollutants. For the limited purpose of designing the treatment system; however, it is assumed that some component of site runoff will be captured and routed to the water treatment facilities. It is assumed that this captured component is limited to paved areas around processing facilities, sediment staging areas, and vehicle decontamination areas. The additional capacity required for this source to be processed by the water treatment system will be determined after site selection and conceptual site layout is completed, during the Phase 1 and Phase 2 Intermediate Design stages.

8.2.3 Solidification/Stabilization

For the option of mechanical dredging, with barged transport of sediments to the land-based processing facilities, it is assumed that a portion of the water introduced during mechanical dredging will separate in the barge and be pumped to water treatment facilities upon arrival at the barge unloading area. The remaining sediments might be unloaded directly into a treatment train of screens, feeders and pug mills for solidification/stabilization. Solidification reagents, such as Portland cement, lime, or fly ash, might be metered from storage silos and mixed with sediments in the pug mill. Reagent dosages could be adjusted on the basis of sediment characteristics (moisture content, particle size and density, and presence of oily residues). Dosage practices will be guided by results from the treatability studies and by experience observed as the program proceeds. Solidification in the barge will be considered, if barge transport of processed material is viable.

The objective of the solidification/stabilization program is to produce a solid matrix that meets the criteria established by the disposal facility, according to its permit requirements. At a minimum, disposed dredged materials must meet the requirement of no free liquid, as measured by the Paint Filter Test. Some landfills may also require toxicity characteristic leaching procedure (TCLP) testing for heavy metals, volatiles, semivolatiles, pesticides, and herbicides. In other cases, measurement of unconfined compressive strength may be required.

Another objective of the solidified/stabilized sediment staging period is to provide a curing period prior to loading into rail cars or barges.

8.3 Process and Equipment Options

A number of process and equipment options are under consideration and will be resolved as treatability study results become available during the Phase 1 and Phase 2 Intermediate Design stages. The following sub-sections cover options within the following categories:

- In-river processing;
- Holding and transfer facilities;
- Land-based facilities;
- Waterfront facilities; and
- Remote facilities.

Each topic is discussed in more detail below:

8.3.1 In-River Processing

As part of the USEPA's facility siting process, an in-river processing option is being considered, which if feasible, would minimize the need for land-based processing facilities. The results of the USEPA's analysis are not available at this time; however, they will be evaluated during the Phase 1 and Phase 2 Intermediate Design stages.

8.3.2 Holding and Transfer Facilities

Equalization or holding facilities are needed both before and after processing. Before processing, such facilities will be used to balance the potential production differences (and downtime) between dredging and processing. After processing, material will need to be temporarily staged while awaiting disposal decisions based on post-processing analytical results.

Three types of holding facilities are considered – offline holding facilities, equalization facilities, and transfer facilities – each of which has different objectives.

An emergency (or offline) *holding* facility is intended to be normally empty, so it is available, when needed, to cover an emergency or unplanned situation. An example is an offline influent storage tank, which would allow hydraulic dredging to continue during periods of brief or extended outages or downtimes within the land-based processing facilities. Backup or redundant processing equipment (and contingency plans) can reduce the need for emergency storage (perhaps making it unnecessary). The need for this contingency and appropriate capacity will be evaluated in intermediate design. Therefore, this system has not been included on the process schematics or general arrangement drawings.

An *equalization* facility is intended to serve as a buffer between two parts of a system operating, by design or expectation, at different rates. An equalization facility is normally expected to cycle between empty and full (or some maximum and minimum). An example is a tank or storage area that is designed to allow dredging to occur 12 hours per day and 5 days per week while processing (dewatering and water treatment) facilities operate 24 hours per day and 7 days per week. The preliminary design assumes that one-day of equalization will be sufficient. This capacity will be evaluated in intermediate design, after dredge types and production rates have been determined.

A *transfer* facility may have some aspects of holding or equalization, but is typically balanced, with inputs and outputs occurring at approximately the same rates. An example would be a receiver sump, where hydraulically dredged materials discharge at the shoreline and are then pumped at approximately the same rate to the processing facility.

Holding and equalization scenarios will be developed for:

- Front-end storage of dredged material slurry (raw or desanded);
- Coarse sediment from hydrocyclones and staging for PCB analysis and loadout;
- Dewatered sediments staging for PCB analysis and loadout;
- Water influent storage for fluctuations in dewatering and stormwater flows; and
- Treated effluent holding for water reuse (e.g., backwash) and emergency holding.

8.3.3 Land-Based Facilities

Numerous process and equipment sub-options are available for designing the land-based processing facilities. Some of these sub-options represent subjective sizing choices (e.g., offline storage capacity), while other sub-options require evaluation of results of characterization data and treatability studies. Outlined below are some process sub-options that will be explored further during treatability studies and the Phase 1 and Phase 2 Intermediate Design stages.

Aboveground receiving basins will be installed near the shoreline to serve as discharge points for hydraulic dredge slurry. These basins will be used as sumps for pumps feeding the size separation facilities. It is anticipated that a relatively short retention time (10 to 20 minutes) will be sufficient. Receiving basin pumps must be able to operate to fill emergency holding tanks. Under usual conditions, the receiver pumps will feed to the size classifiers. Pump curves will be reviewed to select pumps with this capability. Experience at other dredging sites will be considered in selecting this sub-option.

Size separation process sub-options will be reviewed during treatability testing and the Phase 1 and Phase 2 Intermediate Design stages. Process sub-options may include alternative particle size and density splits, and measures to enhance PCB separation in this process. Process sub-options will include comparing screening versus hydraulic size separation.

Aboveground dredge slurry holding basins would be needed to enable processing facilities to operate, while dredging operations are idle or at low production. Even following particle size separation, there will still remain a high concentration of particles which will settle in a quiescent holding basin, therefore, various methods for mixing will be considered. Treatability studies will evaluate the effectiveness of several mixing energy velocity gradients in attaining particle dispersion. Finally, the complete elimination of mixers will be considered. In this case, the dredge slurry holding basin would function both as flow equalization and as a gravity thickener; appropriate mud pumps and bottom configurations would be required in this case. Thickening would likely improve the efficiency of subsequent dewatering steps and could permit smaller sizing of dewatering process options. If a thickening step is employed, the use of chemical treatment to enhance thickening will be considered. This will be evaluated during treatability studies.

The dewatering feed system will require evaluation of appropriate pumps. Some form of positive displacement pumps, such as a progressing cavity, plunger, or gear pumps, will likely be required to achieve necessary pressures while minimizing sludge shear. Dewatering system conditioning chemicals must be determined by bench-scale testing of products from different suppliers applied to different sediment types. These tests are outlined in the TS Work Plan (BBL, 2003d). Conditioning chemicals will require polymer day tanks, dispersers, mixers, and feed pumps. The dewatering system conditioning tanks and mixers must be selected for appropriate detention time, mix energy, and blade configuration. Process sub-options for the dewatering system include plate & frame filters, belt presses, and centrifuges.

Water from the dewatering system will discharge to holding/receiving basins. From there it flows, or is pumped, to sedimentation conditioning tanks where chemicals may be applied to enhance suspended solids removal. Solids separations may be achieved with reactor clarifiers, conventional clarifiers, or direct filtration. The design must establish criteria for the rapid mix zone, coagulation/reaction zone, and settling zone, using results from pilot tests.

Settled effluent will flow to collection sumps where it will be pumped to MMFs. Process sub-options include filtration with and without additional chemicals (polymers). Sub-options can include in-line static mixers and conventional mix tanks. The multimedia filters can employ either two or three separate media.

Carbon adsorber design will estimate the EBCT to achieve optimal removals of PCBs and extend the breakthrough profile, while complying with the substantive water discharge requirements. Sub-options include various carbon sources and specifications.

Solidification sub-options include various reagents; such as Portland cement, lime, and flyash. Pilot testing will provide data to assist design decisions.

Sub-options for treated sediment staging areas include locations relative to processing areas, sizing, and operating logistics. Movement patterns need to be developed to allow efficient conveyance of multiple dredged material types, including clean coarse sediment (potential beneficial use), TSCA and non-TSCA sediments, and various backfill and habitat restoration materials.

The conceptual layouts include space for delivery and staging for 3 to 6 days inventory of backfill material, blending areas, contingency areas (to accommodate inconsistencies with supplies and deliveries), and loadout to barges for transport to river locations. Backfill placement rate is expected to range from 1,000 to 1,200 cy per day. Land requirements of 1 to 3 acres might also include staging for habitat restoration materials. Alternatively, these staging areas can be located at sites apart from the dredged material processing site. See additional discussion on backfill/cap material management in Sections 11 and 12.

Other design details to be considered during the Phase 1 and Phase 2 Intermediate Design stages include covering and air handling/treatment for processing areas, vehicle decontamination areas/washracks, operating and administrative areas, and processed sediment conveyors and load out to rail or barge (including spill containment). Operating and administration needs at the processing facilities may include offices/trailers, change rooms/showers and sanitary facilities, parking lots/roads, and utilities.

8.3.4 Waterfront Facilities

Waterfront facilities include dock/wharf space for various size watercraft and barges. Specific dock areas may be required for unloading dredged materials, reloading processed sediments (if rail yard is to be located at a separate site), unloading or loading of backfill/cap and/or habitat restoration materials, vessel refueling, and access for labor and equipment for dredging, transport, and monitoring/oversight. Various barge loading and unloading approaches may include use of clamshell unloaders and mud pumps.

Additional waterfront issues are discussed in Appendix 8-A – Barge Transportation/Berth Layout Logistics.

8.3.5 Remote Facilities

In addition to on-river dredging activities and shore-based processing facilities, remote facilities may be needed. For example, if it is determined that dewatered or solidified/stabilized sediments are not stable during transit to the landfill(s), it may be necessary to remove and treat separated water and/or add additional solidification reagents after unloading near the landfill. The treatability studies will evaluate this scenario and results will be presented in the *Phase 1* and *Phase 2 Intermediate Design Reports*.

Rail transport and delivery of materials to the site may also involve the use of remote facilities, such as port areas for loading or unloading of containers for barging to the site. These options are discussed further in Section 9.

If remote facilities are used, close communication between the sediment processing site and remote facilities would be required.

8.4 Equipment Selection

The processing facilities described above are similar to the facilities in the USEPA's ROD (USEPA, 2002a). The final sizing and selection of process options will depend on a number of activities yet to be completed. The final SSAP results, DAD, SEDC sampling program, treatability study results, USEPA's facility siting process, and final USEPA-established performance standards all will impact the design. The decision whether to use hydraulic or mechanical dredges (or both) will have a major impact on facility design, especially in the sizing of dewatering and water treatment processes and the ability to recover coarse particulates for beneficial use. Also, the decision to send separated material streams to different permitted disposal facilities versus use of a single disposal facility will influence the equipment selection.

Despite these uncertainties, some preliminary equipment selection, sizing, and conceptual layouts were completed (Figures 8-5 to 8-8). Processing facilities for hydraulic dredging require about 15 acres, while facilities for mechanical dredging require about 5 acres. The option of mechanical dredging with hydraulic slurry is not presented here, but will be evaluated during the Phase 1 and Phase 2 Intermediate Design stages. These layouts are based on data presented in the FS (USEPA, 2000) and assume achieving dredging rates consistent with the USEPA's draft Engineering Performance Standards for anticipated dredging productivity. The range of equipment sizes represents nominal loadings for 5-day per week and 7-day per week operations. These sizes will be modified to account for peak loads, which will be determined during the Phase 1 and Phase 2 Intermediate Design stages. However, the calculations use fairly conservative assumptions for hydraulic and mass loadings to filter presses, settling basins, multimedia filters, and carbon adsorption process options. These loadings will be optimized during intermediate design, based on treatability study results.

8.5 Interrelationship with Other Project Elements

The design of the sediment and water processing project element directly relates to and interacts with other project elements, such as dredging, dredged material transport, transportation, and disposal. The design of these project elements must be integrated to optimize productivity and reduce cost. The design of the processing facilities will incorporate robust features to minimize the impacts of downtimes, startups, impulse loadings (slugs), changes in composition, and the requirements for meeting the USEPA's Engineering Performance Standards for resuspension, residuals, and productivity. Features may also incorporate backup or redundant components, equalization and off-line storage. Within limits, these features are intended to allow continuation of river-based operations when land-based facilities are non-operational and conversely allow treatment and transfer operations to continue when river-based operations are down or rail transport schedules are off.

Specific interrelationships with other project elements are illustrated on Figure 2-2. The inputs to the sediment and water processing design include elements from dredging design, dredged material transport design, and disposal design. Significant influences include selection and design of dredge type and operating criteria, as those affect the quantity and composition of dredged material for processing. Similar influences include the transport methods, rates, volumes, and solids concentrations in the dredged material slurry. Landfill disposal criteria and discharge water quality limits significantly influence the processing facility design, particularly the decision of whether a single disposal facility will be used.

Similarly, the outputs from the processing facilities design affect other project elements, including dredging design, dredged material transport design, and transportation for disposal or beneficial use. Significant influences include the relative locations of processing facilities and disposal facilities, which influence transport distances, transport service providers, and cycle times. Processing facility production rates and limitations influence dredging and transport flexibility. Quantities and physical/chemical characteristics of the processed material influence the transportation and disposal project elements. The sizing of front-end and back-end storage facilities influences the flexibility of upstream and downstream operations during unplanned outages or down times.

8.6 Summary

The sediment and water processing project element must be integrated with other elements of the overall process, and must consider the USEPA's draft Engineering Performance Standards, anticipated productivity rates, and the USEPA's draft Quality of Life Performance Standards (just recently released). In addition, the design of the processing facilities will depend on the results of the SSAP, DAD, SEDC, treatability study, and USEPA siting selection efforts.

During this Preliminary Design stage, facility sizes and conceptual layouts to handle both hydraulically and mechanically dredged material were reviewed. The sediment processing options presented must be considered preliminary at this stage and subject to change during intermediate design. A number of process and equipment options will be reviewed further during the Phase 1 and Phase 2 Intermediate and Final Design stages using data from additional sampling and treatability studies. For instance, both phases of the Intermediate and Final Design stages will further evaluate facilities for dewatering, solidification, water treatment, staging for separating sediments destined for different locations, and loading of the processed material for transport (e.g., via rail car, barge) to a final disposal site. Table 8-3, below, summarizes the Preliminary Design endpoints for the sediment and water processing project element.

Table 8-3 – Summary of Sediment and Water Processing Endpoints for Preliminary Design

Preliminary Design Endpoints	Outcome
Process Components	Dredged material processing facilities include river offloading, size separation, storage, thickening, dewatering, and staging for transport.
	Water treatment facilities include chemical precipitation/flocculation, sedimentation, MMF, and carbon adsorption.
	Solidification/stabilization is assumed for barged mechanically-dredged material.
Process and Equipment Options	In-river processing will be considered as an option to minimize land siting needs for processing, when sufficient information is available.
	Holding and transfer facilities can minimize the impacts of specific equipment outages. Redundant equipment and contingency plans can reduce storage needs.
	Land-based facilities include the major sediment and water processing facilities. Process options will be evaluated during Phase 1 and Phase 2 Intermediate Design.
	Remote facilities cover the scenario of processing at one site, then barging for rail loading at a second site.
Equipment Selection	Equipment selection, sizing, and layout will be completed during Phase 1 and Phase 2 Intermediate Design. Key equipment will include unloading to pug mills for solidification; hydrocyclones; filter presses; clarifiers; dual-media filters; and carbon adsorbers; as well as various pumps, mixers, and storage tanks.

The *Phase 1* and *Phase 2 Intermediate Design Reports* will present more definitive selections of the processing facilities. During the Phase 1 and Phase 2 Intermediate Design stages, the results from the SSAP, SEDC, and treatability studies will be evaluated and discussed as they relate to the design and selection of the processing facilities. The USEPA's selection of the locations for the processing facilities will also be complete during the Phase 1 and Phase 2 Intermediate Design stages, and topographic and geophysical site data will be developed. These data will allow a more definitive selection and sizing of facility components, selection of equipment options, and preliminary layout of components. The basis of design included in the Intermediate Design deliverables for Phase 1 and Phase 2 will include a list of components with a rationale for selection or sizing, including features for redundancy, backup, or emergency holding. The results of treatability studies will also be incorporated into the basis of design. Piping, electrical, mechanical, and utility requirements will be summarized and a revised PFD, piping and instrument diagrams (P&IDs), electrical single-line diagrams, and civil, mechanical, structural, and piping details will be developed. Finally, preliminary specifications will be included in the *Phase 1* and *Phase 2 Intermediate Design Reports* for major equipment items.

9. Transportation for Disposal or Beneficial Use

After the dredged sediments are processed, the material will be loaded into railcars, barges, and/or trucks, and transported to one or more disposal facilities or beneficial use locations. The USEPA has indicated that it expects processed material to leave the project area by rail or barge. Depending on the means by which the material is sent to its final destination, it may have to be transferred from one mode to another before finally being disposed. For example, the lack of rail access to a disposal site may require the material to be transferred from railcars to trucks (transloaded) for final delivery. Materials that meet the standards for beneficial use can also be transported by any of these three modes. Also, as noted in previous sections, in addition to hydraulic pipeline and/or barge transport, trucks may be considered to move material from the river section below Thompson Island Pool to the on-shore processing facility because of the "landlocked" nature of this portion of the river.

This section summarizes the factors considered during the Preliminary Design stage associated with the transportation of processed material for disposal or beneficial use, including the following specific topics:

- Basis of design;
- Design approach;
- Loading and transport;
- Interrelationship with other project elements; and
- Summary.

9.1 Basis of Design

The basis of the Preliminary Design for the transportation or beneficial use of processed material is presented below.

9.1.1 Project Requirements

The ROD requirements (USEPA, 2002a), draft Engineering Performance Standard for productivity (Malcolm Pirnie and TAMS, 2003), and draft Quality of Life Performance Standards (just recently released by the USEPA) represent key requirements for the transportation project element.

The ROD (USEPA, 2002a) specifies that all processed material must be transported from the processing facility site(s) via either rail or barge. The ROD provides an exception for materials designated for beneficial use, which can be transported via rail, barge, or truck. The USEPA's draft productivity standard requires that the project progress at a pace necessary to dredge and remove 2.65 million cy (approximately 4 million tons) of sediment within six dredging seasons, with a target production rate of 530,000 cy per year for Phase 2. As stated previously, based on this production rate and assuming 5 to 7 days per week for operations from early May through the end of October, this schedule will require the project to be designed to process and transport an average of 4,500 to 6,000 tons of material each day. This production schedule is coupled with other constraints, such as the just-released Quality of Life Performance Standards, which set restrictions for air quality, odor, noise, lighting, and navigation.

Given the millions of tons of material to be shipped from the site over the proposed 6-year project duration and the USEPA-established performance standards affecting such transportation, the design of the transportation element of the project must consider the following requirements:

- Adequate capacity and facilities for stockpiling, staging, and loading of processed material at both nominal and anticipated maximum daily production rates;
- Sufficient trackage, dockage and/or parking area for the storage and staging of rail cars, barges and/or trucks to minimize the need for stockpiling of processed material at the processing facility site(s);
- Material handling and loading system that is compatible with both the processing facility output and the type of rail car, container, barge, and/or truck used for transportation;
- Barges to efficiently transport material while accounting for the physical, operational, and regulatory constraints of the Champlain Canal;
- Allocate a sufficient supply of empty rail cars, containers, barges, and trucks to be positioned to load and ship processed material in a safe, efficient, and timely manner without delay or interruption of production and processing; and
- Meaningful commitments from transportation providers to ensure the availability of equipment and crews, and the safe, efficient, and reliable transport of equipment and processed material without delay or interruption of production schedules.

The requirement to transport processed material destined for disposal by barge or rail is based on the USEPA's desire to avoid excessive truck traffic associated with hauling material from the processing facilities on low-capacity rural roads or within residential areas.

The USEPA's commitment in the ROD to utilize barge or rail as the primary means of transportation carries certain risks. First, the constraints placed on canal usage for project purposes may prove to be incompatible with the USEPA's production objectives, and the use of barges may not present an economically or operationally feasible means of transporting processed material to disposal facilities. Second, as noted previously, there is less competition in the railroad industry than the truck or barge industries. Thus, depending on the locations of the final processing facility site(s) and disposal facilities selected for the project, the combination of capital costs to provide rail access and the per-ton haulage costs offered by the railroad could result in substantially higher transport costs than the estimated costs in the FS (USEPA, 2000). Finally and perhaps most importantly, if adequate service commitments cannot be obtained from railroad carriers, the reliability of the transport element of the project will be uncertain, without a method to mitigate the uncertainty (since stockpiling space will be limited and truck or barge backup may not be possible). In recent years, the rail industry has been marked by inadequate service, and this single issue could prove to be a major impediment to the success of the project and needs to be managed diligently in the design. Having a trucking option available may be necessary in order to ensure an adequate and reliable rail service. The need for a trucking option will continue to be assessed as the design progresses.

As described in the RD Work Plan (BBL, 2003a), this *Preliminary Design Report* presents only general requirements for the transportation of processed material. Upon the selection of the final processing facility sites and the identification of acceptable final disposal locations, more detailed transportation design information will be provided in the *Phase 1* and *Phase 2 Intermediate Design Reports*.

9.1.2 Key Process Variables

Several KPVs and uncertainties exist for the transportation project element, including the following:

- **Processing facility output rate:** The rate (in terms of volume and weight) at which the material is processed will directly affect the design of the storage, staging, and loading facilities, as well as the space necessary for empty vessel staging. This variable is important because it sets the basis for processing facility site layout and sizing. Understanding the variability and uncertainty in this rate is critical to successful design.

- **Number of processed material streams:** Multiple material streams (i.e., TSCA, non-TSCA, beneficial use materials, and debris removed from the river during dredging) will affect the number of rail cars and/or barges that must be available to ensure continuous dredging and processing operations. If material cannot be transported efficiently from the processing facility site, additional stockpiling of processed material and possibly the temporary suspension of dredging and processing activities may be necessary.

- **Physical characteristics of processed material:** Grain-size distribution, moisture content, and other geotechnical characteristics of the processed material will affect the design of the material loading equipment and the selection of transportation vessel type. Certain granular materials may be amenable to rail hopper car transport and discharge, while more cohesive materials would require solid-bottom vessels, such as gondolas or intermodal containers.

- **Chemical characteristics of processed material:** In addition to PCB concentrations, which will determine the TSCA versus non-TSCA status of the processed material, other chemical characteristics, such as the Resource Conservation and Recovery Act (RCRA) hazardous waste characteristics, will affect the disposal destination, thereby influencing the transportation project element. Certain non-TSCA materials could potentially require disposal in a RCRA Subtitle C facility.

- **Location of processing facilities:** Accessibility to high-capacity rail lines will depend on the processing facility location. In addition, if barges are to be used to transport processed material, the number of locks that must be negotiated and potential vessel size limitations will be critical.

- **Location of rail yards:** Rail yards capable of handling the staging and assembly of a large number of rail cars into trains will be a necessary component of the transportation design. The need to accommodate an average processed material production rate of 4,500 to 6,000 tons per day results in the need to fill one, 100-ton gondola car every 30 minutes or so. (The frequency of individual car loading would be higher if smaller capacity cars are used and/or if the rail yard hours of operation are reduced.) Therefore, the rail yard must be located at or adjacent to the processing facility site to allow the efficient management of empty and full cars, unless, alternatively, barge shipment of processed material to an intermediate site with sufficient rail yard capacity is used.

- **Rates and service terms of transportation providers:** The service terms by which carriers agree to transport processed material will affect other aspects of the project.

- **Reliable availability of sufficient railcars, barges, and/or trucks:** Sufficient capacity must be available to move the processed material in a timely fashion to meet the USEPA's production objectives. The ability to guarantee a highly reliable transportation system will directly affect the size of the processed material stockpiling and staging areas needed to ensure uninterrupted processing facility operations. Various transportation equipment types, each with unique characteristics and differing availability issues, will be evaluated. Additionally, issues of ownership, maintenance, and off-season storage of equipment used for this project must also be resolved.

- **Number and location of disposal facilities:** The number and location of disposal facilities will determine (among others) the turnaround time required for barges and/or rail cars to deliver processed material to the final disposal site and return empty for reloading. In addition, in the case of rail transport, the disposal facility locations will influence which railroads and/or trucking companies must be contracted with during the RA.

- **Disposal facility offloading capability:** The type of transport vessels (e.g., gondola rail cars versus intermodal containers) will be determined in part by the facility's permitted abilities to offload materials for disposal. If necessary, the design may have to consider the need for infrastructure improvements and potential permit modifications at the disposal facilities to handle the tonnages of materials expected over the life of the project.

- **Number and location of backfill/cap material sources:** The movement of processed material may be combined with a "backhaul" movement of backfill/cap material by the same carrier in emptied railcars, containers, barges or trucks, or other equipment dedicated to this purpose. Significant efficiencies and cost savings can be obtained from such an arrangement if circumstances allow. The uncertainties and KPVs associated with the backfilling/capping project element are discussed in more detail in Section 11, but they include the same carrier, equipment, routing, and service commitment issues discussed in this section.

9.1.3 Design Assumptions

The following assumptions were used for developing the Preliminary Design for the transportation project element:

- Material destined for disposal will be transported by rail and/or barge.
- Material designated for beneficial use can be transported by rail, barge, or truck.

- Processed material will be disposed of in one or more commercial facilities located outside the Hudson River Valley.
- Based on an assumed average daily production rate for dredging of 3,000 to 4,000 cy per day (which, as noted above, is based on a target Phase 2 production rate of 530,000 cy per year combined with an assumption of 5 to 7 days of dredging per week) and an estimated conversion factor of 1.5 to convert from in-situ cy to tons of processed material (note that this conversion factor may be revised based on the results of the treatability studies), the average processed material production rate will range from 4,500 to 6,000 tons per day.
- Processed material with PCB concentrations equal to or greater than 50 mg/kg will be transported to a TSCA-approved disposal facility.
- Processed material with PCB concentrations less than 50 mg/kg can be transported to either a Subtitle D or a TSCA-approved disposal facility.
- Consistent with TSCA, TSCA-regulated sediments (i.e., those with > 50 parts per million [ppm] PCBs) will not be intentionally diluted with cleaner (non-TSCA) material (< 50 ppm) so as to recharacterize material from TSCA to non-TSCA material. Any materials that may be added during sediment processing (e.g., stabilizing agents) will be accounted for in the determination of TSCA versus non-TSCA waste, such that the fraction of such added materials will not be used for dilution in this classification.

9.2 Design Approach

In this Preliminary Design stage, the various means by which USEPA's project objectives could be met were assessed, applying the parameters and constraints imposed by the project area and by the USEPA. However, until the final locations of the processing and disposal facilities are known, only general requirements for loading and transporting processed material can be provided. Moreover, as set forth above in sub-section 9.1.2, several KPVs remain unresolved.

As part of the Preliminary Design stage, GE investigated what railroad infrastructure and facilities need to be constructed in the project area to meet the USEPA's production objectives. For purposes of this analysis, it was assumed that the average daily production rate would equal a nominal 4,500 tons per day (which is at the low end of the 4,500 to 6,000 tons per day assumption). It should be noted that the rail infrastructure designed for 4,500 tons, 7 days per week could accommodate 6,000 tons, generated 5 days per week. During the Phase 1 and Phase 2 Intermediate Design stages, once the average and peak production rates are better known, these assumptions will be further evaluated to ensure that the railroad infrastructure and facilities can handle the expected volumes. The results of this preliminary investigation are summarized below in sub-section 9.3.1 and Appendix 9-A.

In addition, GE met with representatives of each railroad that could currently provide direct rail service to the FCSs, including CPR, CSXT, GRS, and BKRR. At these meetings, GE gathered information on: 1) existing rail line capacity; 2) the ability to connect existing trackage to a new rail yard at each of the candidate processing facility sites; 3) rail car storage and staging capability on the candidate sites and in the vicinity of the Upper Hudson River; 4) restrictions and limitations on rail car type (flat car, gondola, hopper) and train length; and 5) other system capability and limitations.

GE has also initiated a preliminary assessment of rail routings, access to disposal sites by railroad and trucks, and possible terms and conditions for rail carriage. While most potential routings involve transportation entirely within the United States, at least one routing would entail moving processed material on the lines of CPR through Canada and back into the United States for final disposal. The regulatory aspects of this alternative are being investigated.

The viability of barging processed material is being assessed, and the related infrastructure and facilities needs are being developed. The results of this analysis will be presented as part of the Phase 1 and Phase 2 Intermediate Design stages. Preliminary information related to the potential transportation of processed material via barge is presented in Appendix 8-A.

At this time, no analysis has been performed on alternatives that would involve trucking processed material other than beneficial use materials directly from the project area. However, trucking in combination with barge or railroad transport is being investigated in major part to develop options that will promote competition among various types of carriers.

In all cases, arrangements will be negotiated with transportation providers that enable the regular, seamless movement of large volumes of processed material from the processing facilities into transportation equipment and to final disposal locations in a safe, relatively economical, and operationally feasible manner. As explained in sub-section 9.4 and elsewhere in this *Preliminary Design Report*, the arrangements with transportation providers represent a key component of an interrelated process that begins with dredging and ends with final disposal. It is therefore critical that the contractual commitments made by such providers to transport materials produced and/or needed by the project are consistent with the production goals, and that the service can be provided within the existing and established constraints for this project. The ability and willingness of transportation providers to commit to providing such service will be ascertained as the project moves into the Intermediate and Final Design stages.

9.3 Loading and Transport

This sub-section summarizes the information developed during the Preliminary Design for loading and transport via rail, barge, and, in the case of beneficial use materials, trucks.

9.3.1 Rail Loading and Transport

Due to the lack of sufficient rail infrastructure at each of the FCSs, to transport processed material in the volumes and time periods described above via rail, new rail yards and related facilities will be designed and constructed. The rail yard will accommodate the staging, loading, assembly, and movement of rail cars as a train. Rail yard design is a complex matter that depends heavily on the number and type of rail cars that must be accommodated, the land area available for rail line construction, and the site geometry and topography. An overview of rail yard design options that could potentially be applied to the processing facility sites is presented in Appendix 9-A.

Several types of rail cars could be considered for shipping processed material, including gondola rail cars, hopper rail cars, and/or intermodal containers on flat rail cars, each of which has different capacities. The type of rail car used for the project will depend on the operational requirements of a potential rail carrier, the size of the site, and also in part upon the unloading capability of the selected disposal facility. For example, if one disposal facility utilizes a remote container transfer facility to deliver materials by truck, and a second disposal facility has rotary dump facilities to handle bulk material shipments, then the processing facility rail yard must be designed to accommodate both intermodal containers and gondola rail cars, provided that the site's size and topography permit such construction.

The carrying capacity of a rail car determines the number of rail cars that must be staged at or near the processing facility, which directly affects the layout and size of the rail yard. For example, assuming a single stream of processed material, accommodating a 4,500-ton-per-day processing facility output would require 45 gondolas or hopper rail cars with 100-ton capacity to be loaded and moved each day. While these rail cars are being loaded, another 45 empty rail cars will need to be available at or nearby the site to minimize the downtime between the end of loading one train and the start of loading the next. If containers on flat rail cars are used, because of their smaller capacity (around 20 tons per container) 75 flat cars per day will be required to meet the production schedule (assuming three containers per car), with nearby storage for at least another 75 additional empty flat cars so that the supply of rail cars does not interfere with the processing plant output. The actual number of containers that would be loaded and transported on a railcar will depend on, among other things, the ability of the site to manage both rail tracks and container loading equipment. Depending on the distance from the rail loading facility to the disposal facility and the time required to make a round trip, as many as 1,800 rail cars may need to be committed to the project at any given time. The availability of this number of cars must be confirmed as part of the latter design stages.

Because at least three types of rail cars could be used at the processing facility site, the preliminary processing facility design must consider the different ways in which these rail cars may be loaded. This loading requirement and processing plant daily production rate will dictate the type and amount of equipment required to load rail cars daily and meet the overall project schedule.

Gondola and hopper rail cars are commonly loaded by either of two ways. In each of these design options, a locomotive will be required to operate at the processing facility on a full-time basis. First, the cars can be moved and "spotted" by a locomotive under a fixed structure that contains the processed material to be loaded. For example, rail cars can be spotted under a stationary bin, hopper, or silo that contains a specific material type. After the rail car is loaded, the train is moved to spot the next empty rail car for loading. The process is repeated until all materials in a particular material stream are loaded or all the rail cars are loaded for a particular processing plant daily output. Gondola and hopper rail cars can be spotted under a stationary conveyor that can load one or more material types. These conveyors can obtain their materials from a bin, hopper, or silo, or can load themselves with a bucket arrangement. Conveyors can also be fed by earthmoving equipment such as front-end loaders, bulldozers, backhoes, and/or draglines or clamshells.

A second way to load gondola and hopper rail cars is to spot them in the general vicinity of a stationary bin or loading area where a machine or portable piece of equipment can load one or more rail cars before the set of rail cars or train must be moved and relocated. The most common example of this is a front-end loader that works out of one or more fixed material locations and loads a number of rail cars before the train is moved.

The loading of containers on flat rail cars is usually done in one of two ways. Under the first method, empty containers can be removed from rail cars, placed on a truck chassis and then moved to a stationary conveyor or front end loader for material placement. Once full, they return to the rail car by truck for reloading. The second method to keep the containers on rail cars and to push the rail cars under a fixed structure for loading by gravity such as a bin, hopper, silo, or fixed conveyor. The rail cars can also be moved to a fixed material pile location where they would be loaded by a front end loader, a backhoe, a clam or a portable conveyor.

The condition and characteristics of the processed waste stream being loaded and the variability of these parameters will be critical variables that may favor one method of loading or the other, or, conversely, may eliminate certain loading methods from further consideration. These variables will be further defined during Intermediate Design using the results from the results of the treatability studies.

Once rail cars are loaded and assembled into trains at the rail yard, they will be moved onto tracks owned and operated by the railroad serving the processing facility for transportation to the selected disposal location. Preliminary options for disposal are discussed in Section 10.

9.3.2 Barge Loading and Transportation

Using barges to transport processed material from the processing facilities to the final disposal sites or to an intermediate barge-to-truck or barge-to-rail transfer facility is being considered as part of the project design. Several variables must be defined to determine if using barge transport for this purpose is viable, including the processing facility locations, number of locks that must be negotiated within the river, availability of barge unloading facilities, etc. Also, the feasibility of using barges as part of the transportation element of the project will also be affected by the navigation requirements in the USEPA's Quality of Life Performance Standards (just recently released).

Additionally, using barges to transport processed material will require the construction of additional facilities at the processing facility sites, namely loading berths for loading of processed material which do not interfere with the offloading of dredged material. Barges will be loaded with processed material via either the same crane used to offload the barges, or through a separate barge loading conveyor system. It may be determined that it is more efficient and cost-effective to load the river hopper barges using a separate conveying system.

If the material is to be loaded into an intermodal container, the container will be picked up and placed on a deck barge via a much larger and portable crane or a container-handling forklift. From the treatment facility, the containers will then be transported via deck barge and tugs to a separate facility.

Further details of the barge transport analysis are provided in Appendix 8-A.

9.3.3 Truck Loading and Transportation

Based on the requirements of the ROD (USEPA, 2002a), truck transportation of processed material is to be limited to materials designated for beneficial use, although it may also be necessary to consider utilizing trucks for transporting unprocessed material to the processing facility, particularly from the land-locked area of the river. Using trucks to haul beneficial use materials will require a separate material storage location at the processing facility and a separate truck staging and loading area. Most likely, depending on the volume of materials for which a beneficial use has been secured, dump trailers will be loaded at the facility using typical earth-moving equipment (e.g., front-end loaders moving materials from the stockpile to open-top trailers for transport off site).

Loaded trucks will be moved onto the roadway system from the processing facility for delivery at the final beneficial use location. The primary roadways serving the remaining candidate facility sites would have adequate capacity to accept truck loads of this type.

9.4 Interrelationship with Other Project Elements

The transportation project element is closely interrelated with and depends upon other project elements (see Figure 2-2). For example, the inputs to the transportation element are influenced directly by: 1) carrier availability and willingness/ability to provide service that meets the USEPA's production goals and performance standards; 2) sediment and water processing locations and waste streams (i.e., TSCA/non-TSCA volumes for disposal, processing facility production rates, sediment physical characteristics, sediment chemical characteristics, and back-end staging capacity at the processing facility); 3) the disposal project element (i.e., the final disposal location may affect the selection of transportation methods); and 4) backfill sources and types, to the extent that rail cars and/or barges may be used for back haul of backfill materials. The transportation project element is also influenced by the dredging and dredged material transport project elements, through their influence on sediment and water processing as well as barge transport. Any change in one of those project elements (i.e., sediment and water processing, dredging, and dredged material transport) can impact the means by which processed material is transported to disposal locations and the final disposal location for the material.

Similarly, the output from the transportation project element directly influences disposal. For example, selection of a particular carrier or combination of carriers and modes can result in narrowing the list of available disposal sites. Production rates, total tonnage, transload capacity, and carrier mode are all critical inputs for evaluation of the disposal element. The disposal facility's ability to accept material via rail, barge, or truck at the required rates will have a key impact on which mode or combination of modes of final transportation is selected. Specific disposal facility waste receipt and unloading capabilities (e.g., current and planned facility capacity or the ability to handle gondola rail cars but not intermodal containers) will influence the design of the processed material staging and loading facilities, as well as the design of the rail yard layout and operational logistics at the project area. Similarly, the choice of multiple disposal facilities versus a single site able to accept all waste streams from the project will have major effects on both the sediment processing and the staging and loading of processed material. Multiple waste streams (TSCA or non-TSCA) will require multiple staging and loadout areas, while a single waste stream would require a single staging and loadout capability. The identification of a viable beneficial use for a fraction of the processed material may require that the processing facility design include the facilities necessary to accommodate transportation of processed material via trucks.

Each of the numerous parts making up the overall transportation element of the project will become more focused during the Intermediate and Final Design stages, as well as during implementation of Phase 1 dredging of the project.

9.5 Summary

The Preliminary Design of the transportation project element initially evaluated the viability of using either rail or barge for the transportation of processed material to the final disposal location(s). Several interrelated KPVs, from dredging and processed material transportation to final disposal facility location and capacity, remain unresolved at this stage.

Table 9-1 (below) summarizes the Preliminary Design endpoints for the transportation project element.

Table 9-1 – Summary of Transportation for Disposal or Beneficial Use Endpoints for Preliminary Design

Transportation Mode and Availability	Outcome
Availability of rail transport	Rail transport viability at the remaining FCSs is being evaluated. Information has been collected from local carriers; preliminary discussions have taken place, and a preliminary rail yard design for handling 4,500 tons per day has been prepared. However, at the present time, it is unclear whether necessary service arrangements can be obtained from these rail carriers.
	The railroad (s) used and the number and type of cars required depend on the location and size of the processing facility, railroad operational capability and cooperation, use of containers, average and maximum tons of waste to be moved per day, and location and capabilities of disposal facility sites.
Availability of barge transport	Barge transport of processed sediments depends on viability of river transport between processing facility and disposal facility, potential efficiencies to be gained by movement of processed sediment by river from one land-based location to another, and loading and offloading capabilities at both origin, and interim and final destination.

The *Phase 1* and *Phase 2 Intermediate Design Reports* will present more detailed analysis of the transportation project element, using information on the following aspects of the project that influence this project element:

- Location of processing facilities;
- Dredging production rates based on actual dredge areas to be removed;
- Number, volume, and type of waste streams (e.g., TSCA, non-TSCA, beneficial use, debris);
- Transportation providers and rates and terms for service;
- Ability of rail carriers to provide service required to meet project objectives;
- Economic and operational feasibility of barging;
- Extent of infrastructure and capital investment at processing sites and elsewhere in project boundaries;
- Final Engineering Performance Standards and their influence on production volumes;
- Final Quality of Life Performance Standards and their effect on operational capabilities;
- Location, capabilities, and requirements of disposal sites;
- Type of equipment required to transport material;
- Need for trucking of processed material;
- Ownership and maintenance of transportation equipment;
- Resolution of topographical and other site-specific issues with processing facility locations;

- Results from treatability studies;
- Type and volumes of backfill material needed for project (to the extent that rail cars and/or barges are used for back hauling backfill materials);
- Location of backfill sources; and
- Feasibility of transporting backfill material by various modes.

10. Disposal

The disposal element of the Hudson River project involves the unloading of processed material at one or more disposal facilities, in accordance with the disposal facility's permit conditions. Potential beneficial use of a fraction of the processed material is also addressed as part of this project element. This section summarizes the efforts to preliminarily identify possible disposal locations for both TSCA and non-TSCA materials in preparation for developing a short list of viable candidates for consideration and selection during the Phase 1 and Phase 2 Intermediate and Final Design stages. Specifically, 6he following topics related to the disposal element of the Preliminary Design are discussed below:

- Basis of design;
- Design approach;
- Estimation of disposal quantities and basis for TSCA designation;
- Unloading and disposal;
- Beneficial use options;
- Interrelationship with other project elements; and
- Summary.

10.1 Basis of Design

This sub-section discusses the project requirements, KPVs, and design assumptions associated with the disposal of processed material, debris, and spent process material from the Hudson River project.

10.1.1 Project Requirements

The USEPA's draft Engineering Performance Standard for productivity represents a key project requirement for the disposal project element. As stated in previous sections, based on information in the ROD (USEPA, 2002a), the selected remedy will generate an estimated 4 million tons of processed material. Given the requirements in the USEPA's draft productivity standard, this will require an average of between 4,500 and 6,000 tons of processed material to be loaded and transported each day during a dredging season (based on assumptions of 5-day to 7-day per week operations). The processed material must be unloaded and disposed of efficiently at one or more permitted disposal facilities to keep up with the daily production and transportation requirements. The disposal facilities must have adequate capacity to manage the tonnage of materials generated on a daily, monthly, and yearly basis.

Design of the disposal element of the remedy must consider the following requirements:

- PCB concentration and physical characteristics (e.g., moisture content) of the processed material requiring disposal;
- TSCA approval status for the disposal facility, or facilities, accepting materials with PCB concentrations greater than or equal to 50 mg/kg;
- Location of the final disposal facility, or facilities, outside the Hudson River Valley;
- Ability of the disposal facility, or facilities, to accept waste shipments via rail, barge, and/or truck; and
- Capacity of the disposal facility, or facilities, to accept the total volume of processed material and at the rate received.

Disposal facilities permitted pursuant to RCRA Subtitle D and state solid waste management regulations ("non-TSCA" disposal facilities) can accept non-hazardous materials with PCB concentrations less than 50 mg/kg, provided that the material has no free liquid and the facility has no special permit conditions restricting this specific waste. Materials having PCB concentrations of 50 mg/kg or greater must be disposed of in TSCA-approved disposal facilities.

The ROD (USEPA, 2002a) states that the potential use of a locally sited disposal facility (i.e., a facility located within the Hudson River Valley) for sediments dredged from the Upper Hudson River was eliminated from consideration during the FS process.

In addition, the ROD dictates that all materials destined for disposal must be transported from the sediment processing site(s) via rail or barge. The ROD provides an exception for materials designated for beneficial use, which may be transported via rail, barge, or truck (USEPA, 2002a). Given the significant volume of processed material to be generated by the project over its intended 6-year duration identifying final disposal locations (with adequate total capacity and the ability to handle the anticipated daily and monthly volumes) is a critical aspect of the design.

These project requirements influence the selection of potential disposal facilities for the project by favoring disposal facilities with a significant disposal capacity with either direct rail or barge service, rail-to-truck transfer, or barge-to truck transfer capabilities (within a reasonable distance). Moreover, the requirement that rail be the primary mode of transporting processed material out of the project area reduces the feasibility of using multiple disposal sites on a daily basis when compared to using trucks, given the logistics of train operations and routing.

10.1.2 Key Process Variables

The following KPVs and uncertainties are associated with the disposal project element:

- **Total volume of material to be processed and transported:** Estimates of dredged material quantities used in the FS (USEPA, 2000) are based on historic data. More recent data from the SSAP will be considered in the DAD Reports to determine more precisely the volume of dredged materials. In addition, uncertainties associated with the precision of various dredge systems could result in a significant increase in the total amount of material to be processed and disposed. The volume of dredged sediment (not its weight) will be the primary variable in these studies. Following USEPA approval of the DAD Reports for the relevant areas, the *Phase 1* and *Phase 2 Intermediate Design Reports* will provide revised estimates for use in recalculating disposal quantities.
- **TSCA/non-TSCA threshold:** The criteria used to determine which materials will require disposal in a facility with TSCA approval will have a significant impact on overall disposal logistics. The USEPA used a conservative criterion of 32 mg/kg in estimating the amount of TSCA material to be generated by the project, while most solid waste (non-TSCA) disposal facilities can accept materials with PCB concentrations up to 50 mg/kg. The final threshold concentration will be based on the specific waste characterization requirements of the selected disposal facilities.
- **Volume-to-weight conversion assumptions:** Estimates of disposal quantities used in the FS (USEPA, 2000) assume a conversion (density) factor of 1.512 tons of processed material per cy of in-river sediment to be dredged. As noted elsewhere in this report, a conversion factor of 1.5 tons per cy has been used for the purpose of Preliminary Design. The actual density could substantially vary from this assumed value, resulting in a significant under- or over-estimation of disposal quantities. The findings from the treatability studies, SSAP, and SEDC Program, and results from the sediment and water processing design will be used to refine the disposal quantities during the Phase 1 and Phase 2 Intermediate Design stages.

- **Rail accessibility and unloading capacity:** Capability of the disposal facilities to accept various types of rail cars is an important design factor. Not all rail-to-truck transfer facilities located near disposal facilities can handle bulk materials (e.g., gondola rail cars), which would necessitate the use of intermodal containers for processed material shipment or the construction of transfer facilities capable of handling bulk materials. The use of intermodal containers will impact all aspects of the project's processing and transportation elements. The requirements for the sediment processing facility's rail yard and the logistics for material handling and loading would vary considerably depending on whether the facility could handle containers, gondolas, or both.

- **Rates and service terms of transportation providers:** The terms upon which providers agree to transport processed material will affect other aspects of the project, including the location of the disposal facilities. The inability to obtain service commitments consistent with required production rates will adversely impact the entire transportation and disposal chain.

- **Availability of sufficient railcars, barges, and/or trucks to meet production objectives:** The USEPA's production objectives will only be met if sufficient capacity is available to move the processed material in a timely fashion. Additionally, issues of ownership, equipment maintenance and off-season storage must be resolved.

- **Disposal facility location:** The distance from the processing facilities to the disposal facility, or facilities, will directly affect the cycle time required to transport processed material and return the empty vessels (rail cars, containers, and/or barges) for reloading. Longer cycle times will require more equipment be available and may also necessitate larger on-site processed material staging areas so dredging and processing can continue while awaiting the return of empty vessels.

- **Disposal facility capacity and waste receipt permit restrictions:** Many disposal facilities have operating permit restrictions on the tonnage of wastes that can be received on a daily, weekly, monthly, quarterly, and/or annual basis. Additionally, all facilities have both physical and permit limitations on the total amount of materials that can be accepted over the life of the site. Viable disposal facility candidates for this project must have adequate capacity to handle the anticipated periodic and total project waste tonnages.

- **Disposal facility waste origin restrictions:** Some potentially viable disposal facilities have restrictions or moratoria on accepting wastes from certain regions or states. Others are required to levy a state tax on imported wastes that, in some cases, is higher than the disposal cost on a per-ton basis. These variables must be taken into account during the design of the disposal element of the project.

- **Disposal facility compliance status:** Facilities must maintain acceptable regulatory compliance status during the life of the project (see 40 CFR § 300.440)
- **Viability of "monofill" disposal:** A single TSCA-permitted facility with adequate capacity may agree to accept all processed material from the project, either in an existing cell or in a new cell constructed specifically for and dedicated to the Hudson River project – for purposes of the Preliminary Design, this concept is referred to as a "monofill." The monofill concept, if possible, would result in significant simplification of sediment processing, segregation, testing, staging, loading and transport logistics.
- **Potential beneficial uses:** Beneficial use of a fraction of the processed material may be possible, allowing for alternate (i.e., truck) transportation methods and lower disposal costs. If a suitable use is identified, additional sediment processing and material staging areas at the processing facilities would likely be required.

10.1.3 Design Assumptions

The following assumptions were used to develop the Preliminary Design of the disposal project element:

- Material destined for disposal must be transported out of the Hudson River Valley by rail and/or barge, but trucks may be used as part of the overall movement once the material is outside the project area.
- Beneficial use material can be transported by rail, barge, or truck.
- Processed material will be disposed of in one or more commercial facilities located outside the Hudson River Valley.
- Average processed material production rate will range from 4,500 to 6,000 tons per day, based on a Phase 2 target production rate of 530,000 cy per year, assumptions of 5-day to 7-day per week operation, and a conversion factor of 1.5 (to convert from in-situ cy to tons).
- Processed material with PCB concentrations equal to or greater than 50 mg/kg will be disposed of in a TSCA-approved facility.
- Processed material with PCB concentrations less than 50 mg/kg can be disposed of either in a Subtitle D or a TSCA-approved facility.
- The transport of processed material will not cause a change in the physical characteristics (e.g., the release of free water), which would affect the acceptability of the material in a disposal facility.

- Consistent with TSCA, TSCA-regulated sediments (i.e., those with > 50 parts per million [ppm] PCBs) will not be intentionally diluted with cleaner (non-TSCA) material (< 50 ppm) so as to recharacterize material from TSCA to non-TSCA material. Any materials that may be added during sediment processing (e.g., stabilizing agents) will be accounted for in the determination of TSCA versus non-TSCA waste, such that the fraction of such added materials will not be used for dilution in this classification.

10.2 Design Approach

To start the process of identifying the facilities that will receive processed material from the Hudson River project, GE issued a request for Statements of Interest (SOIs) to a number of commercial disposal facilities throughout the United States and Canada in August 2003. SOIs were sent to several commercial entities (e.g., Waste Management, Allied Waste Industries, and Republic Services), as well as a number of individual independent sites. The SOI request was intended to provide facility-specific information on a number of topics, including the following:

- Existing disposal capacity;
- Permitted and planned future disposal capacity;
- Permit requirements, conditions, and limitations;
- TSCA approval status;
- Availability of rail service, either directly or via nearby existing or potential rail-truck transfer facilities;
- Availability of barge service, either directly or via nearby existing or potential barge-truck transfer facilities; and
- Transportation equipment limitations and permit requirements.

Table 10-1 summarizes the responses, and Figure 10-1 shows the approximate locations of the TSCA and non-TSCA disposal facilities that indicated interest in the project. It should be noted that while all disposal facilities with TSCA authority in the United States were sent the SOI request, the list of non-TSCA (i.e., Subtitle D) disposal facilities that were sent the SOI request was limited to sites with significant capacity in the northeastern United States and/or those owned by major commercial waste management companies.

As information is received from the potential disposal facilities, follow-up discussions will be held with select candidates on possible contracting strategies, costs, planning needs for capital improvements necessary to accept materials from the project, and capacity guarantees, etc. These discussions will be ongoing during the Phase 1 and Phase 2 Intermediate Design stages, and it is anticipated that the *Phase 1* and *Phase 2 Intermediate Design Reports* will provide a short list of the disposal facilities that best meet the project requirements.

10.3 Estimation of Disposal Quantities and Basis for TSCA Designation

The current USEPA estimate of 2.65 million cy (approximately 4 million tons of material requiring disposal) will be modified using the results from the SSAP and DAD during the Phase 1 and Phase 2 Intermediate and Final Design stages. Final volumes and tonnages (following processing) will be estimated based on known characteristics of the material, data from previous projects, and results from the treatability studies.

The USEPA also estimated the quantity of dredged material that would exceed TSCA criteria. Although most facilities that do not have TSCA approval can accept materials with PCB concentrations less than 50 mg/kg, the USEPA used a conservative 32 mg/kg threshold for purposes of computing the TSCA/non-TSCA split (USEPA, 2002a). Table 10-2 presents a summary of the USEPA's estimated disposal quantities by TSCA/non-TSCA classification, as well as by river section. These estimates are expected to change, and will be recalculated during the Phase 1 and Phase 2 Intermediate Design stages, as the results of the pre-design testing from the SSAP, treatability studies, and the approved DAD work become available. Additionally, if the TSCA threshold of 50 mg/kg in processed sediment is consistent with the requirements of the selected disposal facility, it will be used as the basis for determining disposal requirements, which affect the estimated quantities of TSCA versus non-TSCA materials. Consistent with TSCA, TSCA-regulated sediments (i.e., those with > 50 parts per million [ppm] PCBs) will not be intentionally diluted with cleaner (non-TSCA) material (< 50 ppm) so as to recharacterize material from TSCA to non-TSCA material. Any materials that may be added during sediment processing (e.g., stabilizing agents) will be accounted for in the determination of TSCA versus non-TSCA waste, such that the fraction of such added materials will not be used for dilution in this classification.

Finally, since the "monofill" potential exists for the purpose of evaluating potential disposal facilities, a capacity to accept a daily production rate of 4,500 to 6,000 tons must be assumed during the design phase.

10.4 Unloading and Disposal

This sub-section addresses the preliminary assessment of unloading and disposal needs for the project by summarizing the information provided by individual disposal facilities in their responses to the SOI requests.

10.4.1 TSCA-Approved Facilities

Currently, nine disposal facilities in the United States have federal approval under TSCA to accept solid wastes containing PCB concentrations at or above 50 mg/kg. SOIs were received from all nine of these facilities during the Preliminary Design stage. The total disposal space available at these sites (both permitted and future expansion areas) ranges from 4 million cy to over 40 million cy (depending on the facility).

Of these nine disposal facilities, two facilities have existing direct rail access, with on-site rail-to-truck or rail-to-dray unloading capabilities. One of these sites has adequate rail offloading capacity to accept the currently assumed daily production of 4,500 to 6,000 tons of processed material, while the other would need infrastructure improvements, and potentially permit modifications, to handle this output.

Of the remaining seven TSCA-approved sites, five have existing off-site rail-to-truck transfer capabilities within 15 miles of the facility. Three of these sites have rail-to-truck transfer capacity in excess of 6,000 tons per day. Two have existing capacity on the order of 1,000 tons per day, and would need infrastructure improvements, and potential permit modifications, to be able to accept the assumed daily production rate of 4,500 to 6,000 tons of processed material.

None of the TSCA-approved disposal facilities has direct barge access for the delivery of wastes, although one facility has a barge-to-truck transfer capability at a port within 10 miles of the site.

Based on the SOI responses, adequate TSCA waste disposal capacity may to be available in the United States to accommodate the Hudson River project. Transportation to a number of disposal facilities by rail or barge is possible, but the facilities would likely need infrastructure improvements to provide the offloading and/or rail-to-truck transfer capacity necessary to accept the anticipated average daily volume of processed material output. The engineering and administrative ability to make these improvements is currently unknown and will be evaluated during later design stages.

10.4.2 Solid Waste (Non-TSCA) Facilities

Hundreds of disposal facilities throughout the United States have approval to accept solid waste containing PCBs at non-TSCA concentrations (typically less than 50 mg/kg). The initial SOI focused on facilities in the eastern and midwestern United States and Canada (although several sites in the western United States were included in the SOIs from multi-site waste management companies). Total available (permitted and future expansion) disposal space at the non-TSCA facilities that provided responses to the SOI ranges from less than 1 million cy to over 350 million cy.

Of the non-TSCA disposal facilities responding to the SOI, approximately 10 have direct rail access with capacities ranging from 200 tons per day to over 4,000 tons per day. Another 10 to 15 have access to nearby (within 15 miles of the facility) rail-to-truck transfer facilities. Of these, many would require significant infrastructure improvements and permit modifications to be able to accept the anticipated volumes of material. Two sites reported existing or planned off-site barge-to-truck transfer capabilities within 15 miles of the disposal facility.

Based on the SOI responses, adequate TSCA waste disposal capacity is available to accommodate the Hudson River project. Transportation to a number of non-TSCA facilities by rail or barge is possible, but the facilities would likely need infrastructure improvements to provide the offloading and/or rail-to-truck transfer capacity necessary to accept the average daily processed material output. The engineering and administrative ability to make these improvements is currently unknown and will be evaluated during later design stages.

10.4.3 Monofill Option

In the SOI request, information was also requested regarding the potential for using an existing TSCA-approved facility as a monofill (i.e., a single location to accept all processed sediment, regardless of its PCB concentration and TSCA status). This approach would offer the advantage of eliminating the need for managing separate waste streams leaving the processing facilities, reducing the logistical demand of multiple staging and loading areas, material testing and segregation, and separate unit train construction. The primary disadvantage of the monofill concept is that the higher per ton disposal cost that TSCA-approved facilities normally demand would apply to the entire 4 million tons of processed material, instead of only the TSCA (50 mg/kg or greater) material.

Of the TSCA-approved facilities, several have permitted capacity with the capability to accept all of the material from the project. Additional discussions with these facilities to further explore the feasibility and cost of operating a monofill for the project will be conducted during the Phase 1 and Phase 2 Intermediate Design stages.

10.5 Beneficial Use Options

The FS (USEPA, 2000) and ROD (USEPA, 2002a) anticipate that a fraction of the processed material may qualify for a Beneficial Use Determination (BUD) in accordance with state solid waste management regulations. In New York and many other states, BUD materials (once approved as such by the solid waste management regulatory agency) are not subject to state solid waste management regulations provided they are beneficially used in a manufacturing process to make a product, or as an effective substitute for a commercial product. BUD materials generated during sediment processing can be transported by rail, barge, or truck (USEPA, 2002a). To receive a BUD for a selected waste stream, an application must be submitted to the state solid waste management regulatory agency (e.g., the NYSDEC) documenting the following:

- The chemical and physical characteristics of the material under review and a plan for monitoring the characteristics of the material during its proposed beneficial use;
- A known or reasonably probable market for the intended use of the material; and
- A demonstration that the use of the material in the proposed manner will not adversely affect human health and safety, the environment, and natural resources.

Because any final BUD will require approval from the state in which the beneficial use will occur, it cannot be included as a Final Design consideration until treatability study data are available and necessary approvals have been obtained. However, the following potential beneficial uses for a limited fraction of the processed material have been identified:

- **Alternate daily cover at approved sanitary disposal facilities:** Currently eight disposal facilities that provided responses to the SOI request have the capability to accept BUD materials for this use. This potential beneficial use could apply to coarse-grained material (e.g., sand and gravel) that is separated from the dredged material during processing. The acceptable PCB concentration for materials designated for this beneficial use would be determined by the specific disposal facility that would receive the material.

- **Fill material for mine reclamation:** A number of unreclaimed mines in New York, Pennsylvania, and other northeastern states can accept dredged materials for reclamation purposes. This potential beneficial use could apply to coarse-grained materials such as sand and gravel with low or non-detectable PCB concentrations.
- **Select river habitat reconstruction materials:** Cobbles and boulders separated from the dredged material during processing and washed to remove sediment residuals could potentially be used as select structural materials for use in habitat replacement and reconstruction.
- **Select river backfill materials:** Clean granular materials (i.e., sand) separated during sediment processing could potentially be used as backfill materials in the river, depending on the PCB concentrations and the specific backfill grain-size specifications for a particular area of the river.

These potential beneficial uses, and others, will continue to be explored during the Phase 1 and Phase 2 Intermediate Design stages.

10.6 Interrelationship with Other Project Elements

The disposal project element has several interrelationships with other project elements (see Figure 2-2). As expected, the input to the disposal project element is influenced directly by the output of the transportation project element (i.e., final transport production rate, total tonnage, transload capacity, and transport type). In addition, due to the strong influence that sediment and water processing exerts on transportation, the disposal project element is also indirectly influenced by sediment and water processing rates.

Further, the ability for the disposal facilities (or in the case of a monofill solution, the single facility) to accept materials via rail or barge (at the rate it is generated) is critical to the throughput and continuity of the overall process – from dredging and dredged material transport, to processing and processed material staging and loadout. Specific disposal facility waste receipt and unloading capabilities (e.g., the ability to handle gondola rail cars versus intermodal containers) will significantly affect the design of the processed material staging and loading facilities, as well as the design of the rail yard layout and operational logistics.

The choice of multiple disposal facilities versus a single, monofill disposal solution will significantly affect the staging and loading of processed material; multiple waste streams will require multiple staging and loadout areas, while a single waste stream would require a single staging and loadout capability. In addition, certain components of the dredged material processing sequence (e.g., size separation intended to minimize the volume of TSCA materials requiring disposal) may not be required under the monofill disposal scenario.

Similarly, the identification of a viable beneficial use for a fraction of the processed material may require that the processing facility design include additional sediment processing and staging components, as well as the logistics required to accommodate transportation of processed material via trucks. Thus, certain changes in the disposal process have the potential to directly impact several other project elements.

10.7 Summary

The Preliminary Design process for the disposal project element identified potentially viable disposal facilities to accept TSCA and non-TSCA processed material. A number of disposal facilities have the capability to accept materials for disposal via rail or barge, although many would require significant infrastructure improvements to accept materials at the volume and rate anticipated. Disposal facility capacity and waste receipt capability is a KPV that will significantly affect the RD for the entire project, from dredging through processed material transportation. Additional information will be gathered from candidate disposal facilities throughout the Phase 1 and Phase 2 Intermediate Design stages.

Table 10-3 (below) summarizes the Preliminary Design endpoints for the disposal project element.

Table 10-3 – Summary of Disposal Endpoints for Preliminary Design

Preliminary Design Endpoint	Outcome
Basis for TSCA/non-TSCA designation	Based on information provided by candidate disposal facilities, the TSCA threshold of 50 mg/kg in processed material is expected to be used as the basis for the TSCA/non-TSCA designation.
Availability of disposal locations	Several TSCA disposal facilities that meet (or can be upgraded to meet) project requirements are available.
	Several non-TSCA disposal facilities that meet (or can be upgraded to meet) project requirements are available.
	Some TSCA disposal facilities may offer viable monofill options to accept all wastes from project.
Availability of beneficial use scenarios	Three or more potential markets for BUD materials may be viable. This option will be further explored as part of Phase 1 and Phase 2 Intermediate Design.

The *Phase 1* and *Phase 2 Intermediate Design Reports* will provide a list of the most viable disposal locations for TSCA and non-TSCA materials (and possibly a monofill solution). In addition, a more detailed analysis of potential beneficial uses for a fraction of the processed material will be provided in the *Phase 1* and *Phase 2 Intermediate Design Reports*.

11. Backfilling/Capping

Following removal of PCB inventory from the river, the areas dredged will be backfilled or capped (as appropriate) to reduce final surface PCB concentrations and to support the habitat replacement and reconstruction. Although the extent and location where backfilling/capping is to be employed will not be established until dredging and subsequent residuals analytical results are available, the FS (USEPA, 2000) and ROD (USEPA, 2002a) estimated approximately 850,000 cy (1.2 million tons) of backfill placement.

This section identifies the design methods for the backfilling/capping element. A key basis of design for this element is derived from the draft Engineering Performance Standard for dredging residuals. As described in the draft residuals standard, backfill/cap selection will be based on residual concentrations after dredging. As such, the design process will continue during the dredging operations, with each dredge area being evaluated, based on the results of post-dredging residuals sampling and considerations for habitat replacement and reconstruction. As discussed further in this section, the remedial design for this element will account for the need to finalize the design during remediation. Specific topics discussed below include:

- Basis of design;
- Design approach;
- Backfill/cap material sources;
- Engineered cap material;
- Backfilling/capping process options;
- Interrelationship with other project elements; and
- Summary.

11.1 Basis of Design

This sub-section discusses the project requirements, KPVs, and design assumptions associated with the backfilling/capping element.

11.1.1 Project Requirements

Clean material (backfill or cap) will be placed in dredged areas outside of the navigation channel to reduce final surface PCB concentrations and provide substrate for habitat restoration. The materials used for this purpose will be designed with guidance set forth in USEPA documents including the ROD (USEPA, 2002a), and the draft Engineering Performance Standards (Malcolm Pirnie and TAMS, 2003). The draft Quality of Life Performance Standards (just recently released by the USEPA) may also influence the methods and means for backfill placement or cap construction and will be considered during the Phase 1 and Phase 2 Intermediate Design stages.

In the FS (USEPA, 2000) and ROD (USEPA, 2002a), the USEPA estimated that approximately 850,000 cy of material would be needed to backfill areas targeted for dredging (approximately 25% of the volume of sediment removed during dredging activities).

The USEPA's draft residuals standard applies to the backfilling/capping design. Note that the requirements discussed below are based on the current draft version of the residuals standard. If the final Engineering Performance Standards differ from the current draft, the project requirements resulting from the standard may likewise change.

The draft residuals standard requires the collection of surface sediment samples following confirmation that the design cut-lines have been achieved. A nominal 5-acre CU will be defined for the post-dredging sampling program and the application of subsequent statistical evaluation of the post-dredging surface sediment Tri+ PCB concentration data. The analytical results from those samples will be compared to the action levels in the draft residuals standard, and the required actions set forth in the performance standard will then be undertaken (see sub-section 4.1.2 for a description of the draft residuals standard).

In areas where the residuals standard has been achieved (an average surface concentration less than 1 ppm Tri+ PCB, either in the nominal 5-acre CU itself or in conjunction with a 20-acre average), clean backfill will be placed. The concept of a 20-acre joint evaluation was developed to maintain flexibility where the mean residuals concentrations in selected 5-acre CUs are only slightly higher than 1 mg/kg Tri+ PCBs. If a CU has a mean residuals concentration of greater than 1 mg/kg Tri+ PCBs but less than or equal to 3 mg/kg Tri+ PCBs, and the average concentration in the 20-acre joint evaluation area that contains the CU is 1 mg/kg Tri+ PCBs or less, backfill may be placed with testing of the backfill surface after placement.

The backfill testing will be accomplished by collecting surface sediment samples (0 to 6 inches) of the backfill after it is placed, using the same grid spacing used for the residual sediment sampling. The mean concentration of Tri+ PCBs in the backfill surface samples must be 0.25 mg/kg Tri+ PCBs or less. If this criterion is not met, then either the non-compliant areas of the backfill layer need to be removed and replaced, or additional backfill must be placed until re-testing verifies that the criterion is achieved.

In cases when dredging alone does not result in less than 1 ppm Tri+ PCBs (either CU mean or 20-acre joint evaluation mean), two options will be available. The first option is to re-dredge, while the second option is to construct a subaqueous cap. Where a maximum of two re-dredging attempts are conducted and the 1 ppm Tri+ PCBs goal is still not met, a subaqueous cap will be constructed as required by the residuals standard. Capping is also required for any individual sample points with Tri+ PCB concentrations greater than 27 mg/kg or more than one sampling point with greater than 15 mg/kg within a CU. The purpose of the cap is to isolate residual PCBs and provide resistance to erosion. As such, the design approach will be to develop several designs for backfilling/capping that consider the possible circumstances that may be encountered during actual remediation. This would provide a series of pre-approved backfill and cap designs (e.g., prototype designs) that can be selected during remediation. The design will also provide protocols for field changes to accommodate unforeseen conditions that will inevitably be encountered. As with the backfill, the surface of the capped areas (i.e., upper 6 inches) must achieve an average post-construction Tri+ PCB concentration of less than 0.25 mg/kg. The extent and type of subaqueous capping will be determined based on residual Tri+ PCB concentrations at the dredged surface and the river conditions in that area. Therefore, the location of areas requiring capping and the type of cap required will not be finalized until results from the residuals testing are available.

The backfill/cap material must be acceptable for unrestricted open water placement, under Section 404 of the Clean Water Act (CWA), Section 10 of the Rivers and Harbors Act, and the State Protection of Waters Law, which establish requirements for the discharge of dredged or fill materials to the waters of the United States, or the waters of the State, respectively (see Section 13). Under Section 404 of the CWA, acceptability of the material from the standpoint of both potential water column and benthic effects requires chemical characterization. The evaluation of the acceptability of backfill/cap material will be accomplished using appropriate techniques as presented in the *Evaluation of Dredged Materials proposed for Discharge in Waters of the U.S. – Testing Manual* (Inland Testing Manual) (USEPA/USACE, 1998) and the *Evaluation of Dredged material Proposed for Disposal at Island, Nearshore or Upland confined Disposal Facilities* (Upland Testing Manual) (USACE, 2003b).

11.1.2 Key Process Variables

The KPVs related to the design of the backfill and cap process include those variables related directly to design of the backfill/cap itself such as the results of dredging (both extent of dredging, bottom conditions, and residual Tri+ PCB concentrations achieved), physical and chemical characteristics of the backfill/cap material, habitat requirements, and site-specific characteristics of the area (i.e., proximity to the navigation channel, river dynamics, bathymetry shoreline conditions, structures, and obstructions), as well as variables related to the transport, handling, and placement of the material. A brief discussion of these variables is presented below:

- **Dredging footprints:** All dredge areas outside of the navigation channel are scheduled to be either backfilled or, if required by the residuals standard, capped. The dimensions of the dredging, therefore, directly influence the dimensions and volume of the backfilling/capping project element. The rate of dredging also influences the rate at which backfilling or capping can be performed.
- **Residual Tri+ PCB concentration:** The draft residuals standard specifies how, within each CU, the average and sample specific Tri+ PCB concentrations are used to determine whether backfilling alone, or capping of select areas is required. The pattern of residual PCB concentration will be used to define the capping footprint and type of cap (assuming capping is needed).
- **Backfill surface Tri+ PCB concentration:** Should average surface Tri+ PCB concentrations exceed 0.25 mg/kg after placement of the backfill, selective excavation of backfill in the non-compliant areas, and replacement with new backfill or additional backfilling may be required.
- **Site-specific characteristics related to PCB transport and uptake by biota:** A number of characteristics, including sediment organic carbon content can be used to estimate the potential mobility and subsequent bioavailability of PCBs migrating through a cap. These characteristics will be considered in the cap design.
- **Chemical leachability of backfill/cap material:** The results of the chemical leaching tests will help determine acceptability of materials for placement within the river.
- **Sorptive capacity of cap material:** The effectiveness of a cap in sequestering PCBs from biota or overlying waters depends on the sorptive capacity of the isolation layer. The primary measure of the sorptive capacity of the prospective capping material is the TOC content
- **Water depth:** Water depth will affect/limit the type of equipment that will be used for the backfilling/capping process, including equipment for transporting and placing the backfill/cap material. Water depths will not be known until the locations and final depths of the dredge areas are determined.

- **Proximity to navigation channel:** Dredged areas within the navigation channel will not be backfilled. If capping is necessary in the navigation channel, navigational depth requirements will be used to define final elevations of the cap.
- **River hydraulics:** The magnitude and probability of occurrence of the hydrodynamic forces will determine the size requirements for material to remain stable in the riverbed under certain design conditions. Similar analysis of these forces will be required to determine whether protection requirements are needed for shallow/shoreline areas. The river hydraulics will also affect the logistics of backfill placement (barge) operations.
- **In-river infrastructure/obstructions:** Once the exact location of the dredge areas have been determined, in-river structures will be mapped and identified as potential obstacles that may interfere with the backfilling/capping process. Each obstruction's effect will be assessed on an individual basis.
- **Desired habitat substrate:** The desired habitat characteristics, as determined by the habitat replacement and reconstruction project element, will be a primary factor in determining the backfill properties and the design of the upper layer of the backfill or cap.
- **Backfill/cap material sources:** In addition to determining the characteristics of the materials themselves, the selection of material source (or multiple sources) for backfill and capping material may determine or restrict the modes of transportation considered. It may also affect storage and material handling requirements at the sediment processing facility, if that facility is used to store and/or load these materials. Should blending or augmentation be required, some backfill/cap material sources may be able to accomplish this task off site. The acquisition and transportation of backfill materials may also be accomplished as part of processed material transportation for final disposal or beneficial use (by backhauling fill materials in the otherwise empty vessels or rail cars).
- **Location of backfill/cap material sources:** Backfill/cap material source locations will be one of the variables that will determine the turnaround time required for barges and/or rail cars to deliver backfill/cap material to the staging site and return empty ones for reloading.
- **Size characteristics of available backfill/cap material:** The size distributions of the potential backfill/cap material influence two design considerations. The first is the relation between anticipated hydrodynamic forces and stable particle size. The second is the extent of losses due to suspended sediment transport in the water column during placement of fine materials. In addition, differential settling between fine and coarse materials may cause separation while falling through the water column during placement.

- **Equipment and mode of transporting backfill/cap material:** Transporting backfill/cap material to the project area by rail or barge may require the construction of additional land-based facilities to enable the loading and transport of these materials to occur without interrupting established production rates.
- **Backfill/cap placement technique and equipment:** The placement technique selected will affect the size and quantity of barges required for material movement. The placement technique and type of equipment selected will determine the number of units that will be required to maintain the desired backfilling/capping production rate.
- **Equipment availability:** It is anticipated that barges, push, boats and equipment for placement will be available. However, the equipment will possibly originate from outside the Hudson River Valley, due to the magnitude of this project.
- **Material use/inventory relations:** Preliminary analysis indicates a minimum of six to eight stockpiles of backfill material will be needed. This would include two to three backfill gradations, two to three cap materials, and two types of stone for armoring. The size of individual inventories will depend on the frequency of use, intended location for use and delivery schedule.
- **Backfill/cap staging facility location and size:** The locations of the backfill/cap staging facilities affect the transport distance for barging, time of transit, and ultimately, number of barges required. Facility size limitations will affect material staging area availability, and transport logistics for the backfilling/capping operation.
- **Location of rail yard:** If the backfill/cap material is transported via rail, a rail yard capable of handling the staging and assembly of an anticipated number of rail cars will be a necessary component of the backfill/cap material transport design. Therefore, such a rail yard should be located at or adjacent to the backfill/cap staging facility site to allow for the efficient management of empty and full cars.
- **Location of barge berthing facilities:** These facilities will be a necessary component of the backfill/cap material transport design. Ideally, they should be located at or adjacent to the backfill/cap staging facility site to allow for the efficient management of empty and full barges.

Note that some of the above variables will be unresolved until dredge work has commenced. Hence, reasonable estimates will be made to develop a suitable range of prototype caps that can be used or modified depending on site-specific conditions.

11.1.3 Design Assumptions

The following assumptions were used for developing the Preliminary Design for the backfilling/capping project element:

- During the project, no major channel modifications (e.g., dam addition/removal) will occur that would significantly change existing river hydraulics.
- Required volumes of backfill/cap material are estimated to be 850,000 cy.
- Cap design will be dictated primarily by Tri+ PCB residuals levels at the dredged surface once the PCB inventory has been removed.
- If used, the resuspension control system will be left in place during backfilling/capping operations (if needed).
- Backfill/cap material will be transported from the source to the project site by rail or barge.
- The maximum barge/scow width was assumed to be 35 ft (navigable width of the canal locks is 43.5 ft), with a maximum barge length of 200 ft. (Note that the maximum lock length is 300 ft.)
- Shallow draft deck barges (i.e., 200 to 500 cy capacity range) could be modified to carry backfill/cap material to reach shallow draft areas, if needed.
- Locks will be staffed and operated as needed to support material/barge movement.
- Schedule assumes operations for two scenarios – 5 days or 7 days per week between early May and mid-November (end of operations consist of shut-down and demobilization; note that dredging is assumed to be completed by the end of October for each season).

11.2 Design Approach

The backfilling/capping design will be integrated with the dredging design. Dredging will be conducted to remove the PCB inventory. The objective of the backfilling/capping project element is to provide for a reduced surface PCB concentration (0.25 mg/kg Tri+ PCB) in an expeditious manner. The backfilling/capping and dredging project elements are also integrated with the habitat replacement and reconstruction project element, as the backfill/cap will either form the final habitat substrate or the base upon which the final habitat substrate will be constructed. At the Preliminary Design stage, the backfill and cap designs include:

- Identification of potential backfill/cap material sources;
- Discussion of appropriate engineered cap materials and identification of possible cap configurations; and
- Identification of process options for transporting, handling, and placing backfill/cap material.

Backfill will be placed over the non-navigation channel dredged areas which meet the residuals standard of less than 1 mg/kg Tri+ PCB. The backfill will be nominally 1-ft thick, with a Tri+ PCB concentration of less than 0.25 mg/kg at the backfill surface after placement. The backfill material will be designed to have stability reflective of the surrounding materials and to reflect the substrate objectives of the habitat replacement and reconstruction in that area. In selecting the appropriate backfill materials to use, consideration will be given to the fact that fish and benthic organisms require a diversity of bottom characteristics to spawn and thrive, including stream bottoms composed of gravels, sands, and fine materials. Thus, to the extent practical, an effort will be made to use backfill materials of varying textures, such as would be found on the bottom of a river.

Implementation of capping at the Hudson River differs from most other sites in that the capping only occurs after in inventory has been removed. The Hudson River capping is intended not to isolate or sequester a significant PCB inventory but rather to manage the PCB in surface sediments that may be available in the short term. It is a contingency in the event that, following dredging to remove the PCB inventory, specific, limited dredged locations do not achieve the mean Tri+ PCB concentrations in the surface sediments as specified in the residuals standard. Thus, capping is not intended to sequester a large inventory of PCBs in the river. In fact, as long as Tri+ PCB residuals are less than about 6 mg/kg, the MPA in the CU would still be below the MPA threshold for River Section 1 (and as such, similar to other adjacent areas that are not being dredged), and PCB residuals would need to be on the order of 20 mg/kg Tri+ PCBs to exceed the River Section 2 MPA threshold. In these circumstances, different cap designs will be developed for areas with residual Tri+ PCBs above 1 mg/kg but less than 6 mg/kg and areas with residuals greater than 6 mg/kg Tri+ PCBs. The capping will have a primary goal of reducing the potential interaction of the residual PCBs with the river environment. The caps will therefore provide an immediate separation of dredging residuals from the overlying water and benthos, while providing reasonable protection against erosion in the short term.

In those areas requiring capping, the design of the subaqueous cap will reflect the residual PCB concentration. In areas with low residual concentrations (1 to 6 mg/kg Tri+ PCB), the low residual PCB mass and the low dissolved phase PCB concentrations associated with those residual sediments limit the potential transport of a significant mass of PCBs. In such cases, the caps would function to sequester the residual PCBs from direct physical contact by biota and to provide a reasonable degree of resistance to erosion. To achieve these objectives, the "low residual" cap will consist of material and thickness based on sequestering the low PCB mass (with a minimum of 1 ft, but potentially greater in some cases) and meeting habitat needs, while providing resistance to erosion similar to non-dredged areas in the vicinity of the removal area.

For areas with higher residual concentrations (> 6 mg/kg Tri+ PCB), the cap will consist of a more traditionally designed engineered cap, with an isolation layer consisting of appropriate materials designed to retard the migration of dissolved PCBs through the cap material, as well as an armor layer, to resist erosion from future river flows.

Where erosion protection is needed, appropriate armor stone will be utilized. No specific guidance exists for the specific recurrence interval event to be used in designing cap armor. However, the velocities and tractive forces associated with an event of various recurrence intervals will be estimated from existing modeling frameworks. The importance of other possible forces such as navigation activity and ice-related processes will also be examined. The required size and thickness of the armor layer can be determined using a variety of standard engineering approaches.

The specific cap locations and cap material characteristics will not be determined until results of the residual sampling are completed for a given CU. Differing environments within the river may require differing cap designs reflecting differences in the residual PCB concentration, as well as differences in hydrodynamics, water depths, sediment conditions, structure interferences, or habitat replacement and reconstruction goals (which may vary along different portions of the river). Prototype caps, following procedures presented in Palermo et al. (1998a, b), will be developed during the Intermediate Design stage to reflect a range of conditions within the two broad categories of residual concentrations described above. Final cap design specifications for a given area may not be available until site-specific conditions are identified in the field following dredging. When required, specifications for an armor layer for the cap will be determined based on design velocities or shear stresses during events likely to occur over the longer term (e.g. 25-year return interval). The coarse nature of the armor materials may also have a secondary function in meeting some of the desired habitat characteristics.

Additional details on the backfilling/capping design approach will be presented in the *Phase 1* and *Phase 2 Intermediate Design Reports.*

11.3 Backfill/Cap Material Sources

A preliminary evaluation of available materials that can be transported to the site by either barge or rail has been conducted. As of the writing of this *Preliminary Design Report*, 32 potential backfill/cap material sources have been identified and contacted. These sources are listed in Table 11-1. Of the 32 sources identified to date, five sources, Peckham Materials Corporation, William E. Daily Inc., William Larned and Son, Troy Sand and Gravel, and Jointa Galusha, have availability to rail or barge for material transportation. Peckham Materials Corporation, William E. Daily Inc., William Larned and Son, and Troy Sand and Gravel identified that their sources contained volumes greater than the estimated 850,000 cy required for this work. Jointa Galusha identified that its source contains approximately half of the material required for this work. At least one of the sites, William Larned and Son's backfill source located at the Brickyard Associates Site in Mechanicville, NY, could also be a candidate to serve dual roles as a backfill source/staging area and a sediment processing site (due to its proximity to the river and its overall size). The suitability of any of these sources for backfill or capping material has not been determined since material design specifications have not yet been determined.

This initial survey of potential backfill/cap material inventories was limited to local sources (within the Upper Hudson River Valley), but there may be opportunities for economical sources beyond the local area. This is especially true if material handling and storage can be minimized. Another option for long distance sources would be to coordinate the supply of backfill/cap material with the round trip movement of processed material. These options will be considered further during the Phase 1 and Phase 2 Intermediate Design stages.

In addition, there might be the potential for obtaining qualified backfill/cap material from materials generated by other tasks. For example, significant amounts of potential backfill/cap material may be generated during site work (grading) or excavation performed to develop waterfront facilities at the processing facility. Also, clean granular materials (i.e., sand) separated during sediment processing could potentially be used as backfill materials in the river. These options will also be considered during the Phase 1 and Phase 2 Intermediate Design stages.

11.4 Engineered Cap Material

Engineering cap material will include granular soils or sediments for the main portion of the cap and, where necessary, will include larger stones (used in the armor layer) to resist hydrodynamic forces. In addition, depending on the particle sizes of the soil/sediment and armor layers, a filter layer composed of intermediate sized granular material or geosynthetic material may be required to stabilize the cap.

Physical characteristics of importance for cap material include density, plasticity, organic content, grain size distributions and specific gravity. As noted earlier, from a water quality perspective, the capping material must be such that it is acceptable for unrestricted open-water placement. The materials considered must also be compatible with respect to desired habitat in each area.

The cap material selection and design will also depend on the amount and concentration of residual Tri+ PCBs. As discussed earlier, cap designs will be developed for areas with residual Tri+ PCBs between 1 and 6 mg/kg and areas with residuals greater than 6 mg/kg Tri+ PCBs. In the former types of areas, given the low residual PCB mass and the low dissolved phase PCB concentrations associated with those residual sediments, a cap that consists of the placement of the regular backfill material (without any augmentation of that material) may be sufficient to sequester the PCBs from direct physical contact by biota. In addition, erosion protection will be provided, as needed, to match erosional characteristics of non-dredge areas in the vicinity. For areas with residual Tri+ PCB concentration greater than 6 mg/kg, the granular cap material will be designed to function as an isolation layer to retard migration of dissolved PCBs. Thus, where additional sorptive capacity is desired (without excessively adding to the thickness of the cap), a soil with higher TOC or more active sorbent (e.g., activated carbon, coke, processed shale, or organoclay) can be blended into the isolation layer material. In addition, for these "higher residual" caps, armor stone will be placed as necessary to prevent erosion under a defined event (e.g., 100-year river flow, vessel forces, ice scour).

Additional materials may also be considered for incorporation into cap designs. Depending on the relative size difference between the materials used in the isolation and armor layers, a filter layer may be required. This filter layer may be either an intermediate sized granular material or a geosynthetic material. In addition, other specialized materials, such as AquaBlok, may be considered for specific uses during the capping process.

Available materials for inclusion in the base layer of the cap will be evaluated based on chemical-specific criteria. Depending on those results, the option of custom blending materials for use in the base layer may be considered. Blending may also be used to achieve select particle size distributions or other considerations such as habitat substrate specifications. Note also that cobbles and boulders, as well as other large woody debris separated from the dredged material during processing may be suitable for use as cap/habitat replacement and reconstruction materials.

Appropriate design hydraulic events will be used to assess the stability of each component. Additional protective measures that are needed will be considered in the Phase 1 and Phase 2 Final Design stages for the backfilling/capping project element.

11.5 Backfilling/Capping Process Options

This sub-section addresses the various process options for the transport, handling, and placement of backfill/cap material. The backfilling/capping process flow diagram, showing the relation of these individual processes, is presented on Figure 11-1.

11.5.1 Transport of Backfill/Cap Material

Backfill/cap material will be transported to the project area by rail or barge. Material will be generally distributed to the placement location by barge. The requirement to transport materials by barge or rail is based on the USEPA's desire to avoid excessive truck traffic associated with hauling material to staging sites on low-capacity rural roads or within residential areas. However, depending on the selected locations of the staging sites, it may be possible to haul material by truck for a short distance directly to the staging sites or primarily from the Interstate highway system, without significant impacts to rural or residential roads. Transporting backfill/cap material via trucking may also be necessary for distribution and placement within the land-locked area and select shoreline locations. The design for transport of backfill/cap material to specific dredge areas includes the following components:

- Source;
- Transport from source to the Hudson River staging site;
- Unloading at staging site;
- Staging;
- Blending (if needed);
- Loading for river transport;
- River transport to dredge areas; and
- River transport return to staging site.

These elements of backfill/cap material transport design are summarized below.

Potential backfill sources will be subject to testing to ensure compliance with project specifications. Specific to the draft productivity standard, source material transportation will be designed to stay within the 6-year timeframe set forth for dredging activities. The current estimate for backfill/cap material is 850,000 cy (based on the ROD [USEPA, 2002a]). Based on the estimated 6-year timeframe, the average backfill/cap material to be transported, unloaded, and distributed for placement is on the order of 1,000 cy per day. The USEPA just recently released the draft Quality of Life Performance Standards, which have standards for air quality, odor, noise, lighting, and navigation. Those standards could affect several aspects related to backfill/cap material transport and will be considered in the Phase 1 and Phase 2 Intermediate Design stages.

As described in sub-section 11.3, the selection of backfill sources will be based on the capacity of specified sources and the ability for transportation to occur by rail or barge to the staging areas. Rail considerations include capacity of cars, rail yard operation hours, management of material handling (loading and unloading), coordination with dredging operations, and locations of staging areas. Barge considerations include capacity, vessel size, adequate dockage space, coordination with dredging operations, and location of staging areas. Requirements described for dredged sediment handling, loading, and transportation in sub-section 9.3, will be similar for the transport of backfill/cap material from the source(s) to the river. These include rail and barge loading and transport infrastructure, rail car types, barge carrying capacity, loading equipment systems, and available rail and barge service. Infrastructure (e.g., rail yard space, handling systems) for the handling of backfill/cap material and for staging area locations may require design and construction of additional handling and transport systems to accommodate the supply of materials to the site. Handling and transport systems will be directly affected by the type and volume of rail and barge used. Existing rail and barge services may have limitations on operating load capacities and hours of operation, which may require special scheduling to meet project demands.

Final design of handling and transport systems from the source to the backfill or cap area will require the understanding of all project elements. Backfill/cap material demand, staging area capability, rail and barge operations and capacity, and locations of backfill/cap sites are key variables that affect the Final Design and operational logistics for this design element. It is anticipated that infrastructure construction, including construction of wharf and staging areas, will be required to facilitate barge transportation of the anticipated quantities of project materials.

Since source material and staging area locations have not yet been selected, only general considerations for this component of the process has been developed during this Preliminary Design stage. Further design information will be provided in subsequent *Phase 1* and *Phase 2 Intermediate Design Reports*.

11.5.2 Handling of Backfill/Cap Material

It is envisioned that backfill/cap material will be stored at the processing facility or alternate sites. Several days of storage capacity will likely be needed for this material (depending on the reliability of material supply and transport options). The staging and storage needs for backfill/cap material were discussed in Section 8.

As part of the Final Design for backfilling and capping areas, some backfill/cap material may require special handling and mixing processes to meet the site-specific objectives. For example, certain materials may be blended to meet project specifications (e.g., organic content, grain size). Should the potential source material not have inherent physical or chemical characteristics that match the requirements of the design (e.g., habitat replacement and reconstruction specifications), materials may be blended/augmented to meet the specification. The blending process will be driven by physical (grain-size) considerations, chemical considerations (e.g. achieving a desired TOC for capping material for the higher residuals cap) or a combination. For the Grasse River Pilot Study, cap material consisted of a 1:1 blend of sand to top soil. Other materials that have been considered to augment the cap isolation layer include activated carbon, and other carbon-based geosorbents (e.g., coke, shale or organoclays).

In addition, the location of the blending process may vary. In some instances, individual quarries may have multiple stock piles which they can blend on site. In other instances, if the source materials are from different origins, the materials may not be processed until they are at a staging area near the river. Another alternative would be to mix material during the act of placement of different materials.

If blending/augmenting is required, field process testing may be needed to optimize the process. Such tests would consist of sampling the blended material to determine if the desired characteristics of blended material can be predicted based on the initial stocks, and to determine the degree of variability in those characteristics in the final blended material. Equipment required for material mixing could include soil batch-mixers, front end loaders, and/or specialty equipment (e.g., Putzmeister, which is basically a long-reach conveyor system).

11.5.3 Placement Techniques for Backfill/Cap Material

Backfill/cap material can be placed in a variety of ways. Nearshore areas, where access is available, may employ direct mechanical placement by land-based equipment. Equipment used for placement may include backhoes, clamshells, end-dumping from trucks, and spreading with dozers (Mohan, 1997; Palermo et al., 1998a, b). Considerations affecting this placement method may include equipment limitations (i.e., reach), site access, and traffic. As noted earlier, transport of backfill and capping materials will not generally be by truck, although in select land-locked and shoreline areas trucking these materials may be necessary.

The placement technique chosen may be a compromise between objectives. Placement options balance the rate and accuracy (with respect to both location and thickness) of placement against the (re)suspension of dredged residuals and the backfill/cap material itself. Placement activities will take place within any resuspension control structure placed in the river for the dredging phase. Therefore, it is important that river velocity be low in those areas so as to not cause undue downstream transport of resuspended backfill materials. These velocity limitations will be further developed during the Phase 1 and Phase 2 Intermediate Design stages.

To dissipate energy of the material impacting the river bottom, two general categories of placement techniques can be used. The first is underwater controlled placement of materials from just above the bottom, limiting the fall distance. The second is to disaggregate the material (being placed at or above the water surface) into particle size fractions that settle individually through the water column. Some applications attempt to combine the two by disaggregating the material through a screening device before allowing it to settle through a series of tubes or another conveyance device.

Submerged placement of materials has included use of both mechanical and hydraulic operating equipment. Submerged diffusers, tremie tube, and sand spreader barges allow placement of cap material with reduced velocities, at deeper water depths, and in a slurry form. Considerations affecting this placement technique may include site hydrodynamics, water depths, and capping material specifications.

Surface discharge using conventional dredging equipment is an alternative method for placing of disaggregated material at the surface. Hydraulic, hopper, and standard barge equipment are typically used. Hydraulic washing of coarse sand off flat-topped barges and transport of slurry through a pipeline coupled with dissipating devices are examples of hydraulic methods. Typically, surface discharge equipment methods are used only when a gradual release of materials is desired over a large area (Palermo et al., 1998a, b). Considerations affecting this placement method may include size of area, physical characteristics of substrate, water depths and site hydrodynamics.

Placement of armor layers can include commonly used techniques employed for streambank and shoreline erosion protection (Mohan, 1997; Palermo et al., 1998a, b). Methods include placement by hand and machine, and dumping from barges. Careful consideration must be given to maintaining design features when using these techniques. Disruption in cap components, creases and anchoring of geosynthetic layer, and differential settling of gravel-sized armor stone are common concerns with placement of armor materials.

Table 11-2, (below) presents a generalized comparison of backfill/cap construction and placement techniques, with assigned rating initially developed for coastal areas. These ratings will serve as a preliminary guide for initial evaluation of the various backfill/cap placement techniques. A more detailed evaluation using site-specific data will be presented in the *Phase 1* and *Phase 2 Intermediate Design Reports*. However, selection of the appropriate backfill/cap construction and placement equipment is influenced mainly by site- and material-specific properties.

Table 11-2 – Comparison of Backfill/Cap Construction and Placement Techniques

Equipment	Water Depth	Material	Accuracy	Resuspension	Mixing	Cost
CDB	Deep	S	Medium	Medium	Low	Low
SD	Both*	All*	High	Low	Low	Medium
SB	Shallow	All*	High	Low	Low	Medium
CB	Deep	S/R	Medium	Medium	Medium	Medium
DWP	Both*	S/Si/C	Medium	Low	Low	Low
SUC	Both*	S/R	Medium	High	High	Medium
MD	Deep	S/R	Medium	Medium	Medium	High
TLD	Deep	S	High	Medium	Low	Medium

Notes:

1. Key: CDB=Conventional Discharge from Barges; SD=Submerged Discharge; SB=Skip Box; CB=Conveyor Belts; DWP=Dry/Wet Pumping; SUC=Surface/Underwater Clamshell; MD=Modified Dredges; TLD=Thin-Layer Disposal; Both*=Deep and Shallow; All*=Sand (S), Silt (Si), Clay ® and Rock ®.
2. Reference: Mohan, 1997.

For the above-listed placement techniques, maneuverability of process equipment to safely and accurately place backfill/cap material is an important factor. Considerations affecting placement are the ability of equipment to maintain position given various site conditions (e.g., water current, strong winds, water depths), ability to change position with relative ease (e.g., using GPS interaction with land-based survey), and control of cap placement with the equipment selected.

For the particular circumstances at the Hudson River, where placing backfill/cap material will be on top of an already dredged surface, with low residual PCB concentrations, controlled placement may be the preferred method. The controlled placement also will usually provide a higher degree of accuracy than other techniques. Using a gentler placement technique such as particle broadcasting could reduce the resuspension of residual materials, but might increase the downstream drift of materials. In addition, the "gentler" the placement (where individual particles settle independently), the more likely that differences in the settling rates of larger coarse particles and smaller, lighter, finer particles will result in a modified distribution after placement.

In certain areas, wet or dry pumping of materials may allow material to be delivered from intermediate areas to the placement location and applied directly.

A 5-acre CU, covered with a nominal 1-ft thickness of backfill, would require slightly more than 8,000 cy of material. A reasonable target placement rate for the backfill would be placement of 100 cy per hour (1,000 cy per day) or coverage of 2,700 ft^2 per hour. This number ideally assumes that there is no inefficiency in placing a uniform 1-ft thickness. Spread rates may initially be increased so that 100 cy covers only 2,000 ft^2 requiring approximately two 10-hour days per acre. Note that this production rate is about twice the rate achieved at a pilot study on the Grasse River (where the production rate achieved was 1,200 ft^2 per hour, using one clamshell releasing material approximately 2 ft above the river bottom for a target thickness of 1 ft).

The cap material placement rate is inversely related to the design thickness of the cap, with slower placement rates necessary for thicker caps to ensure proper placement of multiple layers of material. Based on the sampling grid structure defined in the draft residuals standard, a single node requiring capping can range from 5,500 to 16,600 ft^2, depending on the concentration of adjacent sample points. The average production rate of 1,000 cy per day is consistent with the construction of a cap over a single isolated sampling point per day. Armor placement will take additional time. Backfilling placement rates will benefit from having the largest scale and continuity, with regard to both total size of the areas to be backfill and continuity of those areas, allowing for more continuous operation. Both capping and select habitat related reconstruction will probably be targeted at smaller and likely less continuous areas compared to the backfilling. Depending on the detail of specifications for habitat replacement and reconstruction, some habitat areas are likely to have the lowest production rates.

11.6 Interrelationship with Other Project Elements

The backfilling/capping project element presents a number of interrelationships with other project elements, which are illustrated on Figure 2-2. The design of this project element must ensure that backfilling/capping operations do not interfere with dredging production objectives. The input to the backfilling/capping project element is influenced directly by the dimensions and location of actual dredging. Backfill/cap material transfer rate will also depend on the progress of the dredging operations. Design inputs for backfilling will also be related to the residual Tri+ PCB concentrations remaining after dredging.

The backfilling/capping project element is also strongly interrelated with the habitat replacement and reconstruction project element. The two elements both receive input from and provide input to the other element. As the final backfill or cap surface layer may frequently serve as the substrate for habitat replacement and reconstruction, the material selection process will be performed to most efficiently accommodate both project elements. Habitat replacement and reconstruction will be coordinated with the backfilling/capping processes. Thus, any substantive change in the habitat replacement and reconstruction program may directly alter the backfilling/capping process, and vice versa.

Resuspension control structures that are used during dredging activities may be used during backfilling and capping activities. The backfilling/capping project element, by virtue of handling an estimated 850,000 cy (1.2 million tons) of material, will influence the land-based transportation and processing infrastructure and the water-based transport operations. Backfill/cap material will be transported within the river by means of barge. It is anticipated that an infrastructure including wharf and staging area construction will be required to facilitate the transportation of the anticipated quantities of backfill/cap material by this mode. The backfilling/capping project element may also be interrelated with the transportation of processed material to disposal facilities since backfill/cap material transport may possibly occur as part of an overall round-trip movement of a particular carrier or group of carriers.

11.7 Summary

In dredged areas of the riverbed outside the navigation channel, clean material (backfill or cap) will be placed to cover PCB residuals and provide substrate for habitat replacement and reconstruction. In areas where the residuals standard has been achieved (an average surface concentration less than 1 mg/kg Tri+ PCB, either in the nominal 5-acre CU itself or in conjunction with a 20-acre average), clean backfill will be placed.

For the Hudson River project, 1 ft of clean backfill material will be placed, fulfilling several purposes including, but not limited to, covering dredging residuals, mitigation of bathymetric changes, and establishment of substrate consistent with habitat replacement and reconstruction objectives. Materials that suit both hydraulic stability (relative to existing bed materials) and desired habitat substrate will be selected for placement. Placement will be performed such that the resultant 0- to 6-inch surface has an average Tri+ PCB concentration not exceeding than 0.25 mg/kg. A preliminary evaluation of available materials that can be transported to the site by either barge or rail has been conducted to determine whether an adequate inventory is available locally.

When required by the draft residuals standard, a subaqueous cap will be constructed. The extent and location of areas requiring such capping will therefore not be known until results from residuals testing are available. The caps will be designed to provide a clean surface (not exceeding 0.25 mg/kg Tri+ PCB), and resist erosion. Two general types of caps will be used: 1) the “low residuals cap” (for areas between 1 and 6 mg/kg Tri+ PCBs), which will consist of material (and thickness of 1 ft or more) based on sequestering low PCB mass, meeting habitat needs, and providing erosion protection consistent with nearby non-dredged areas; and 2) the “higher residuals cap” (for areas > 6 mg/kg Tri+ PCBs), which will consist of a more traditionally designed engineered cap, including an isolation layer (with possible augmentation with other materials) and an erosion protection layer designed to prevent erosion under a defined event (e.g., 100-year river flow, vessel forces, ice scour). Prototype cap designs will be developed during the Intermediate Design stage to reflect a typical range of site conditions within these two general categories. The design for both types of caps will be performed in accordance with the procedures presented in Palermo et al. (1998a,b). Prototypes may differ reflecting potential differences in hydrodynamic or habitat considerations. Final specifications cannot be developed until site specific conditions are determined after dredging. Having pre-approved prototype cap designs, which have been developed to address expected ranges of conditions, should streamline field decisions on cap details.

Table 11-3, below, provides a brief summary of the Preliminary Design endpoints for the backfilling/capping project element.

Table 11-3 – Summary of Backfilling/Capping Endpoints for Preliminary Design

Preliminary Design Endpoint	Outcome
Identification of Material Sources	Preliminary survey of 32 material sources has been completed. Restriction to barge or rail transport was identified as the most limiting factor in source acceptability. Several local candidate sites met both transport and capacity requirements.
Engineered Cap	Identification of key components and types of prototype caps has been completed.
	Additional types of materials that may be incorporated into cap design have been identified.
Identification of Process Options	Likely use of rail or barge transportation from source to staging area. Predominant use of barge transport for distribution to placement locations within project area.
	Blending to achieve select physical or chemical specifications of backfill/cap material retained as an option.
	Placement options have been identified and applicability will vary with factors such as initial material characteristics, placement depth, resuspension requirements, etc.

The Phase 1 and Phase 2 Intermediate Design stages will further address the backfilling/capping design, material specification, material transportation, possible need for blending of materials to achieve desired specifications, equipment and placement techniques, considerations for institutional controls, and monitoring program for both cap construction and long-term maintenance.

12. Habitat Replacement and Reconstruction

In accordance with the ROD (USEPA, 2002a), with the exception of the navigational channel, dredged areas will either be backfilled, as appropriate, with approximately 1 ft of clean material to sequester residual PCBs and to support habitat replacement and reconstruction objectives, or where required by the draft residuals standard, such areas will be capped. Since a significantly larger volume of sediment has been targeted for removal by the USEPA (i.e., 2.65 million cy) than is being placed as backfill (i.e., 0.85 million cy), the draft residuals standard will primarily dictate the design criteria and requirements for specific backfill and cap types. Depending on the residual sediment Tri+ PCB levels, the standard will mandate either placing backfill or an engineered cap. As a result, post-dredging conditions in the river will differ from those that exist today.

As provided in the HDA Work Plan (BBL, 2003c), the primary goal of the habitat replacement and reconstruction program is to replace the functions of Upper Hudson River habitats, through the use of both active and passive replacement/reconstruction techniques, to within the range of functions found in similar physical settings in the Upper Hudson River; in light of changes in river hydrology, bathymetry, and geomorphology resulting from implementation of the USEPA-selected remedy; and from possible independent environmental changes that may occur from other factors (e.g., floods, droughts).

The range of functions found in the Upper Hudson River will be assessed by measuring associated structural parameters, as described in the HDA Work Plan (BBL, 2003c). First, the range of structural parameters for Upper Hudson River habitats prior to dredging will be quantified by measuring these parameters both in areas that will be directly impacted by dredging and in those that will not. Then, based on these data, the specific structural parameters to be used as design criteria for the habitat replacement and reconstruction program will be selected to achieve the program's primary goal.

After a given area has been backfilled or capped, design criteria determined from the habitat assessments will be used to develop active or passive designs. These designs will be used to reconstruct or replace habitat parameters at specific locations within an adaptive management framework – the foundation for the habitat replacement and reconstruction program. In adaptive management, the goal of returning disturbed habitats to the desired range of functions is achieved by applying site-specific information in an iterative process of measurement and response. The objectives of adaptive management are met when measurements fall within the range of attainable functions. Therefore, the essence of adaptive management is that no single goal determines "success" or "failure" of a project. Rather, if certain goals are not being met, management responses are applied to "correct" the project trajectory.

Habitat delineation and assessment activities were initiated in September 2003 and will continue through the 2004 growing season. Specifically, the HDA activities undertaken in 2003 included the habitat delineation of all areas and the habitat assessment in candidate Phase 1 areas. The work to be undertaken in 2004 will include the habitat assessment of the remaining areas. These activities are being completed to collect quantitative data for the specific structural parameters to be used as design criteria for the habitat replacement and reconstruction program. Once the habitat delineation and assessment activities have been completed, "conceptual" habitat replacement and reconstruction designs will be provided in the *Phase 1* and *Phase 2 Intermediate Design Reports*. An *Adaptive Management Plan* will address final design criteria for those locations where structural elements of habitats will be reconstructed or replaced. The *Adaptive Management Plan* will be provided as part of the *Final Design Report* for both Phase 1 and Phase 2.

13. Permit Equivalency Analysis

The Hudson River PCBs Site remedy is potentially subject to a variety of federal, state, and local environmental laws. Some of these laws require permits be obtained before certain activities can take place. Because the remedy is being performed pursuant to CERCLA, no federal, state, or local permit is required for work being performed "on site" [42 USC § 121(e); 40 CFR § 300.400(e)]. The USEPA interprets these provisions to exempt "on-site" activities from the procedural requirements of these laws. The work, however, must comply with these laws' substantive requirements. This section identifies the federal, state, and local environmental laws (and other similar laws) applicable to the on-site portions of the remedy; briefly summarizes the requirements of these laws; and describes how the RD and/or RA will satisfy these substantive requirements. The information presented in this section is informed by the USEPA's analysis of ARARs contained in the ROD (USEPA, 2002a).

For purposes of this analysis, the term "on-site" means the Hudson River and "all suitable areas in very close proximity to" the River "necessary for implementation of the response action" [40 CFR § 300.400(e)]. Therefore, "on-site" activities include: 1) all in-river operations, including dredging, sediment transport, backfilling/capping, and habitat replacement and reconstruction; and 2) all near-river operations, including habitat replacement and reconstruction, and construction and operation of any land-based activities to support in-river operations (e.g., processing facilities).

As discussed above, the USEPA has drafted Engineering Performance Standards and just recently released the draft Quality of Life Performance Standards. The final performance standards will govern the performance of the remedy. Engineering Performance Standards establish requirements for dredging-related resuspension, dredging residuals, and dredging productivity, while Quality of Life Performance Standards establish requirements for air quality, odor, noise, lighting, and navigation. Portions of the performance standards are intended to take account of and satisfy the substantive requirements of other laws. For example, the draft resuspension standard is intended, in part, to ensure that drinking water drawn from the Hudson River meets the drinking water standards for PCBs established under the Safe Drinking Water Act. Accordingly, for purposes of this permit equivalency analysis, it is presumed that compliance with an Engineering or Quality of Life Performance Standard will satisfy the relevant substantive requirements of federal and state laws that the standards are intended to address (consistent with EPA's authority under CERCLA). As required by Paragraph 35 of the RD AOC (USEPA/GE, 2003), the design will be consistent with, and fully take account of, these performance standards.

In addition, certain activities being performed as part of the RD, such as the habitat replacement and reconstruction program and the CARA program, are intended to satisfy relevant statutory requirements. For example, the habitat reconstruction/reconstruction program will take into account and satisfy the requirements of federal and state laws which govern mitigation of impacts to endangered species, aquatic vegetation and wetlands that might be adversely affected by the dredging program and other aspects of the RA. The CARA program will provide assurance that the project will comply with federal and state laws governing the protection of cultural resources (e.g., the National Historic Preservation Act, 16 USC § 470, et seq.). Additional details pertaining to these programs is provided in other sections of this *Preliminary Design Report* and in other reports to be submitted under the RD AOC (USEPA/GE, 2003) and are not discussed in detail in this report.

In addition, note that that the permit equivalency criteria (i.e., meeting the substantive requirements of the various permits) will be addressed as part of the Phase 1 and Phase 2 Intermediate Design stages, once the design is more fully developed.

13.1 Federal Laws

This sub-section identifies and discusses the federal environmental laws that might apply to the RA.

FWPCA, 33 USC § 1250 et seq.

Two relevant permitting programs under the FWPCA apply to the remedy. First, discharges of treated carriage water from the processing facilities would typically require a permit under Section 402 of the FWPCA (33 USC § 1342). In addition, permits would be required for discharges of storm water during the construction and operation of these facilities. Such permits would be issued by the NYSDEC, which implements these permitting programs under the State Pollution Discharge Elimination System. While these discharges do not require permits because the RA is being performed pursuant to CERCLA, the FWPCA and relevant state law(s) establish substantive requirements for water discharges. These requirements include effluent limits based on technology and water quality considerations. It is anticipated that applicable effluent limits for the discharge of treated carriage water will be established by the USEPA, taking into account water quality requirements identified by the NYSDEC. Further, storm water discharges during construction and operation of the sediment and water processing facilities will be managed in accordance with the applicable substantive requirements that apply to industrial and construction storm water discharges. The *Phase 1* and *2 Intermediate Design Reports* will specify the necessary controls, if any, needed to meet these requirements (assuming effluent limits for treated carriage water are identified by the USEPA in a timely fashion).

The second permit would normally apply to the discharge of dredged or fill material pursuant to Section 404 of the FWPCA. This permit would apply to the dredging, backfill, and habitat replacement and reconstruction program, and potentially to the construction and operation of the sediment and water processing facilities. Implementing regulations promulgated by the USEPA and USACE establish procedural and substantive requirements that apply to the discharge of dredged material or fill (40 CFR Parts 230 and 231; 33 CFR Parts 320-329). The USEPA's draft Engineering Performance Standards include requirements for the placement of backfill and for limiting resuspension during such activities. In addition, it is anticipated USEPA will establish requirements applicable to in-river operations based on water quality considerations identified by the NYSDEC. Thus, the substantive requirements of the applicable regulations will be satisfied, in part, by making the RD consistent with the performance standards and the water quality considerations identified by the NYSDEC. Consistent with the goals of the habitat replacement and reconstruction program as set out in the RD Work Plan (BBL, 2003a) and the HDA Work Plan (BBL, 2003c); the design will establish specifications for the dredging, backfilling, and habitat replacement and reconstruction program. These specifications will be contained in the *Phase 1* and *2 Final Design Reports* and will take into account the substantive requirements of the relevant regulations, the performance standards, and the water quality requirements established by the USEPA. As noted in sub-section 11.1.1, appropriate techniques such as those presented in the Inland Testing Manual (USEPA/USACE, 1998) and the Upland Testing Manual (USACE, 2003b) will be considered to determine the acceptability of backfill and cap material under Section 404 of the FWPCA.

Rivers and Harbors Act, 33 USC § 403

Under Section 10 of the Rivers and Harbors Act, a permit would typically be required for the excavation or filling of the channel of any navigable water of the United States. The USACE implements the Section 10 permitting program. The dredging and backfill programs would normally trigger this permitting requirement; however, since the program is being implemented pursuant to CERCLA, no permit is required. Implementing regulations promulgated by the USACE establish procedural and substantive requirements that apply to operations subject to Section 10 of the Rivers and Harbors Act (see 33 CFR Parts 320, 321, and 322). The USEPA's draft Engineering Performance Standards include requirements for placing backfill and for limiting resuspension during such activities. In addition, it is anticipated that the USEPA will establish requirements applicable to in-river operations based on water quality considerations identified by the NYSDEC. Thus, the substantive requirements of the applicable regulations will be satisfied, in part, by making the RD consistent with the performance standards and the water quality considerations identified by the NYSDEC. Consistent with the goals established in the RD Work Plan (BBL, 2003a) and the HDA Work Plan (BBL, 2003c), the design will establish specifications for the dredging, backfilling, and habitat replacement and reconstruction program. These specifications will be contained in the *Phase 1* and *2 Final Design Reports* and will take into account the substantive requirements of the relevant regulations, the performance standards, and the water quality requirements established by the USEPA. As noted in sub-section 11.1.1, appropriate techniques such as those presented in the Inland Testing Manual (USEPA/USACE, 1998) and the Upland Testing Manual (USACE, 2003b) will be considered to determine the acceptability of backfill and cap material under Section 10 of the Rivers and Harbors Act.

Solid Waste Disposal Act (SWDA), 42 USC § 6901 et seq.

RCRA requires facilities that treat, store, or dispose of hazardous waste obtain permits (42 USC § 6925). Pursuant to 42 USC § 6926, New York implements the federal SWDA permitting program in lieu of the USEPA. The procedural permitting requirements do not apply to such on-site facilities because the RA is taking place pursuant to CERCLA. It is possible that the permitting requirement would not apply to the sediment and water processing facilities as the facilities may not engage in an activity that would trigger the need for a permit. For example, facility operations may only include sediment dewatering and the preparation of dewatered sediment for off-site transport and disposal (and not "treatment" or "disposal" of waste), and the storage of dewatered sediment at the facilities will likely be for less than 90 days. SWDA and NYSDEC's implementing regulations establish substantive requirements for hazardous waste generators and treatment, storage, and disposal facilities (6 NYCRR Parts 360, 370, 372, and 373). The processing facilities will likely manage hazardous waste, as solid waste with PCB concentrations in excess of 50 ppm is considered hazardous waste under NYS law. To the extent that these substantive requirements apply to activities being performed at the processing facilities (e.g., minimum standards for storage of hazardous waste); methods to satisfy these requirements will be included in the *Phase 1* and *2 Intermediate Design Reports*.

Clean Air Act (CAA), 42 USC § 7401 et seq.

The CAA establishes several programs applicable to "major" stationary sources of air pollutants. These include the Prevention of Significant Deterioration (PSD), Non-Attainment New Source Review (NSR), and New Source Performance Standards (NSPS) (provisions applicable to certain "new" "major sources" [42 USC §§ 7411, 7470-7515]), the National Emission Standards for Hazardous Air Pollutant (provisions applicable to major sources of specified hazardous air pollutants [(42 USC § 7412]), as well as the operating permit program established under Title V of the CAA (42 USC §§ 7661-7661f). All these programs, except for the Title V program, establish substantive requirements to limit emissions from covered sources. It is highly unlikely that any of these programs will apply to the RA. As an initial matter, most of the emissions from this project will come from mobile sources or non-road engines (e.g., dredges, booster pumps, rail engines) which are not regulated as stationary sources. Further, it is unlikely that the processing facilities or other stationary sources that might operate during the RA would qualify as a “major” source under any of these programs, because emissions from these sources are not likely to exceed the established emission thresholds. However, to the extent that any of these programs do apply because the emission thresholds are exceeded, the *Phase 1* and *2 Intermediate Design Reports* will include methods to satisfy the applicable substantive emission requirements of the applicable programs.

In addition to these stationary source programs, federal projects in non-attainment and maintenance areas are required, in certain circumstances, to prepare a “conformity determination” to assess the consistency of the project to the applicable State Implementation Plan (SIP) (40 CFR § 51.853). These requirements only apply if pollutant emissions from the project equal or exceed established thresholds. Further, certain projects, or portions thereof, are exempt from the conformity determination requirement. These exemptions include “Direct emissions from remedial and removal actions carried out under CERCLA to the extent such emissions either comply with the substantive requirements of the PSD/NSR permitting program or are exempted from other environmental regulation under the provisions of CERCLA and applicable regulations under CERCLA” (40 CFR § 51.853(d)(5)). Because, as noted above, PSD, NSR, and NSPS are not likely to be triggered by the RA, this exemption should exclude the RA from the conformity determination requirement established under the USEPA’s regulations.

TSCA, 15 USC § 2605(e)

Pursuant to its authority under Section 6(e) of TSCA, the USEPA has established storage, decontamination, and disposal requirements, including permitting requirements, for PCBs (40 CFR § 761.60 [disposal requirements], § 761.65 [storage requirements], and § 761.79 [decontamination requirements]). The USEPA’s regulations establish a variety of substantive requirements applicable to these activities (although no disposal of PCBs will take place at the sediment and water processing facilities). To the extent that these substantive requirements apply to processing facility activities (e.g., minimum standards for the storage of PCBs); the *Phase 1* and *2 Intermediate Design Reports* will include methods to satisfy the requirements.

Endangered Species Act (ESA), 16 USC § 1531 et seq.

A permit under Section 10(a) of the ESA must be obtained if an action will result in a "take" of a threatened or endangered species. Section 3 of the HDA Work Plan (BBL, 2003c) establishes a process by which the procedural and substantive requirements of the ESA will be met. This process includes consultation with the resource agencies, preparation of relevant biological assessments, and, where necessary, issuance of biological opinions or written concurrence with a determination of "not likely to adversely affect."

13.2 State Laws

State laws could apply in two ways to the RA. First, New York implements permitting programs and establishes substantive requirements under the CWA, SWDA, and CAA. Compliance with the substantive requirements of these state programs will satisfy the requirements of these federal laws. Second, certain state laws establish permitting and substantive requirements, in addition to those imposed by federal law.

SPDES, ECL Article 17, Titles 7 and 8

These provisions implement the FWPCA Section 402 permitting program (i.e., the National Pollutant Discharge Elimination System). The discussion in sub-section 13.1 addresses compliance with the substantive requirements related to the discharge of treated carriage water and industrial/construction-related storm water from the processing facilities

State Protection of Waters Law, ECL Article 15, Title 5

This law and NYSDEC's implementing regulations (6 NYCRR Part 608) regulate several types of activities that may be implicated in the RA: 1) disturbance of the bed and/or banks of a protected stream; 2) construction, reconstruction, or expansion of docking and mooring facilities; and 3) excavation or placement of fill in navigable waters and their adjacent and contiguous wetlands. The dredging and backfill programs and the construction of the processing facilities implicate these regulations. Parties proposing to undertake such activities would typically be required to apply for and obtain a permit from the NYSDEC. Because the RA is taking place pursuant to CERCLA, no such permits are required. The USEPA's draft Engineering Performance Standards include requirements for placing backfill and for limiting resuspension during project activities. In addition, it is anticipated USEPA will establish requirements applicable to in-river operations based on water quality considerations identified by the NYSDEC. Thus, the substantive requirements of the applicable regulations will be satisfied, in part, by making the RD consistent with the performance standards and the water quality requirements. Consistent with the goals of established in the RD Work Plan (BBL, 2003a) and the HDA

Work Plan (BBL, 2003c), the design will establish specifications for the dredging, backfilling and habitat replacement and reconstruction program. These specifications will be contained in the *Phase 1* and *2 Final Design Reports* and will take into account the substantive requirements of the relevant regulations, the performance standards, and the water quality requirements established by the USEPA.

State Freshwater Wetlands Act, ECL Article 24, Title 7

This law requires permits for certain activities, including dredging, excavation, and filling, that take place in freshwater wetlands. The dredging, backfilling/capping, and habitat replacement and reconstruction program, as well as the construction and operation of the processing facilities, have the potential to impact freshwater wetlands. Because the RA is taking place pursuant to CERCLA, no such permits are required. The USEPA's draft Engineering Performance Standards include requirements for the placement of backfill and for limiting resuspension during such activities. In addition, it is anticipated that the USEPA will establish requirements applicable to in-river operations based on water quality considerations identified by the NYSDEC. Thus, the substantive requirements of the applicable regulations will be satisfied, in part, by making the RD consistent with the performance standards and the water quality requirements. Consistent with the goals established in the RD Work Plan (BBL, 2003a) and the HDA Work Plan (BBL, 2003c), the design will establish specifications for the dredging, backfilling and habitat replacement and reconstruction program. These specifications will be contained in the *Phase 1* and *2 Final Design Reports* and will take into account the substantive requirements of the relevant regulations, the performance standards, and the water quality requirements established by the USEPA.

State Solid and Hazardous Waste Laws, ECL Article 27, Titles 7, 9, and 11

These provisions, together with NYSDEC's implementing regulations (e.g., 6 NYCRR Parts 360, 364, 370, 371, 372, 373) establish permitting and substantive requirements for the management of solid and hazardous wastes, in part to implement the federal SWDA. Activities at the processing facilities will include management, storage, and preparation for off-site transport and disposal of both solid and hazardous wastes, and thus are subject to these requirements. Because the RA is taking place pursuant to CERCLA, no permits under these provisions are required. Nevertheless, the *Phase 1* and *2 Intermediate Design Reports* will include details for the facilities that satisfy the substantive requirements of these laws and regulations which govern the management of solid and hazardous wastes.

NYSDEC's regulations (6 NYCRR Part 360-1.15) establish procedural and substantive requirements for obtaining a BUD for waste material. Under these regulations, if the waste material will be beneficially used and qualifies for a BUD, the material ceases to be considered a solid waste. It is possible that materials generated during the RA (e.g., dredged material) might be re-used on site. If so, while the substantive BUD requirements of NYSDEC's regulations would apply, the procedural requirements would not. The possibility of on-site beneficial use of such material will be evaluated during the Phase 1 and Phase 2 Intermediate Design stages (see sub-section 10.5). If the *Phase 1* and *Phase 2 Intermediate Design Reports* propose such beneficial use, they will ensure that the beneficial use satisfies the substantive requirements of NYSDEC's BUD regulations.

State Hazardous Substances and Petroleum Bulk Storage Acts, ECL Article 17, Title 10 and Article 40

These laws, and NYSDEC's implementing regulations (6 NYCRR Parts 595-599, 612-614) establish registration and substantive requirements for the bulk storage of petroleum and hazardous substances. It is conceivable these requirements will be triggered by the storage of such materials at the processing facilities. If these requirements are triggered, the *Phase 1* and *2 Intermediate Design Reports* will include details for the facilities that satisfy the substantive requirements of these laws and regulations.

State Air Pollution Control Law, ECL Article 19

This law and NYSDEC's implementing regulations (6 NYCRR Part 201) implement the permitting programs and substantive requirements of the Federal CAA. Subject to certain exemptions, these requirements impose registration and permitting requirements on specified stationary sources of air pollution. Persons proposing to construct or operate covered sources would normally be required to apply for and obtain a permit from the NYSDEC. Because the RA is taking place pursuant to CERCLA, no such permit is required for on-site response activities. As with the federal CAA, a number of these programs only apply to "major sources" and thus are not likely to apply to the RA. In contrast to the federal CAA, however, the NYSDEC's regulations impose permitting requirements on "minor" sources, subject to a number of exemptions (6 NYCRR Part 201). The *Phase 1* and *2 Intermediate Design Reports* will include methods to satisfy these regulations or others (e.g., controls required under "General Process Emission Sources," 6 NYCRR Part 212), which establish substantive requirements and are applicable to the activities to be conducted as part of the RA.

Public Lands Law, Article 6, Section 75

Article 6, Section 75 of the Public Lands Law requires that applications for use of underwater land owned by the state be submitted to the New York Office of General Services. This law applies to wharfs, docks, piers, jetties, moorings, or other structures constructed in, on or above state-owned underwater land, as well as the placement of fill on such land. Because the bed of the Hudson River is state-owned land, implementation of the RA will require that permission be obtained from NYS to "use" these state lands.

State Canal Law

The State Canal Law places authority for regulating activities in the NYS Canal System in the NYS Canal Corporation. It is highly likely that portions of the RA will take place on canal lands. The Champlain Canal, part of the NYS canal system, is located in the navigational channel of the Upper Hudson River, and some of the properties being considered for the processing facilities are located on canal lands.

The NYS Canal Corporation has promulgated regulations governing navigation in the NYS canal system (21 NYCRR Part 151). The substantive requirements contained in these regulations will be considered in the preparation of the *Phase 1* and *2 Intermediate Design Reports*. The NYS Canal Corporation also administers a permit program for the use or occupancy of canal lands (21 NYCRR § 156.4). The *Phase 1* and *2 Intermediate Design Reports* will include methods to satisfy the substantive requirements of this permit program, to the extent it applies to the RA.

The NYS Canal Corporation also issues permits to allow vessels to use the NYS canal system and locks. The NYS Canal Corporation uses the permits to track the number of vessels that pass through the locks and provide a semi-quantitative estimate of annual canal usage. Permits are required for commercial craft, and user fees for lock and lift passes are imposed (21 NYCRR § 150.2). The permitting program does not apply to the RA because it is being performed pursuant to CERCLA.

13.3 Local Laws

It is conceivable that county or municipal governments have enacted laws or ordinances that would otherwise require a person to obtain licenses of permits for the construction and operation of the processing facilities. These laws may also impose zoning and construction requirements. Because the RA is being performed under CERCLA, no licenses or permits will be needed. Further, to the extent that such local requirements conflict with, and present an obstacle to, the performance of the remedy, they may be preempted by CERCLA. The USEPA has not yet selected the final locations for the processing facilities. Therefore, it is unclear whether such local laws or ordinances would establish substantive requirements applicable to the construction or operation of these facilities. Upon selection of the final sites, an analysis of the substantive requirements of local laws and ordinances potentially applicable to each site will be conducted, including an evaluation of the extent to which such requirements are preempted by federal law. The results of this analysis will be discussed with the USEPA to determine whether and how these requirements should be addressed by the design.

14. Preliminary Construction Schedule, Contracting Approaches, and Construction Specifications

This section provides a preliminary construction schedule, an assessment of contracting approaches, and a preliminary list of construction specifications for the dredging program, consistent with those requirements listed in sub-section 4.3.1 of the RD Work Plan (BBL, 2003a).

14.1 Construction Sequencing

In this Preliminary Design stage, only a conceptual discussion of schedule and construction sequencing is possible. Attempting to put specific dates on the schedule would be premature at this time due to the vast number KPVs that are unresolved. In addition, the RA lead (i.e., the entity which will be contracting the construction activities) has not been determined and will be established in parallel with the RD activities. Moreover, it has not yet been determined that the project can be completed under the parameters established by the USEPA. Nevertheless, to provide a list of the key construction-related events necessary for the project to proceed, the following outline is provided.

On-Shore Activities

Several on-shore activities will need to be completed, in the following sequence:

- The USEPA will select the Phase 1 candidate sites that meet the site selection criteria.
- As project design and optimization advance, the specific site or sites available to the project will emerge. The USEPA will then initiate acquisitions of the sites.
- When it is clear which sites will be acquired, the Final Design of the land-based processing facilities can be completed.
- Upon USEPA approval of the Final Design for the land-based processing facilities and associated Phase 1 project elements, contracts for the on-shore work can be let out for bid, negotiated and awarded.
- Upon completion of contracting, the following activities will occur:
  - Additional investigations to support foundation designs and installations, site grading, etc. (as needed).
  - Ordering of processing equipment.

- Mobilization.
- Excavations for foundations and equipment pads.
- Grading for roads, rail, and site drainage.
- Trenching for site utilities (e.g., power, water, communications).
- Installation of:
  - On-site and off-site rail and roadway infrastructure;
  - River front infrastructure (bulkhead, dockage, loading and unloading equipment);
  - Support buildings;
  - Staging areas;
  - Sediment handling and processing equipment;
  - Water treatment plant storage tanks and processing equipment;
  - Site security measures; and
  - Monitoring equipment.

- Sediment and soil excavations for bulkhead development.
- Following equipment installation, testing and shakedown of all installed equipment will need to occur prior to processing any dredged material.

Water-Based Dredging Activities

Upon approval of the Phase 1 Final Design, and in parallel with the on-shore activities, identification and prequalification of dredging, barging, rail, disposal, and support contractors can be completed by the RA lead. At that time, the remaining work can be sent out for bid, negotiated, and awarded, and followed by the activities listed below:

- Procurement of equipment and initiation of mobilization activities.
- After shakedown of the on-shore sediment processing and dewatering facility process equipment, installation of specified sediment resuspension control systems as needed.
- Sediment removal to provide river access to the sediment processing facility.

- Initiation of sediment removal at a reduced rate to shakedown the in-river portion of the sediment removal/disposal program.
- After the in-river shakedown period, increasing the production incrementally in an attempt to meet the maximum production rate (while still striving to adhere to all of the performance standards).
- Backfilling or capping of the dredge areas prior to removal of sediment resuspension control systems.

Transportation and Disposal of Processed Material

As remedial design continues past this preliminary phase, the potential means by which processed material can be transported for final disposal, and the locations of disposal sites, should come more into focus. It is expected that upon approval of the Phase 1 Final Design the negotiation and awarding of final contracts to transportation providers and disposal facilities would occur. In addition to the construction activities discussed above, activities associated with transportation and disposal of processed material could include the acquisition of necessary railcars, barges, or trucks; and the construction of necessary infrastructure and other modifications to a disposal facility or facilities.

Additional Activities

The following additional activities will be undertaken, consistent with the objectives of the habitat replacement and reconstruction program, as well as continuation of Phase 2 dredging:

- The sequencing of restoration work will be developed during the Final Design stage.
- Upon completion of the first season of dredging, the in-river and on-shore equipment would be demobilized and/or winterized.
- Phase 1 results would be independently reviewed after data from the project become available.
- Prior to initiation of Phase 2 dredging, the following activities would need to occur:
    - USEPA approval of the Phase 2 Final Design, including any necessary redesign of Phase 2 based on the post-Phase 1 evaluation and peer review results; and
    - Acquisition and construction of additional on-shore facilities needed for Phase 2 work, if any.

14.2 Contracting Approaches

Viable approaches to contracting are constrained by the need to first develop detailed specifications as part of the RD. Numerous groups are interested and are currently participating in several aspects of this project. As a result of community interest, the USEPA has committed to a transparent and open public process that allows all parties to be informed and to have input into key design decisions. This approach has been incorporated into the RD AOC between GE and the USEPA (USEPA/GE, 2003). GE will provide design documents that have increasing level of detail as the design proceeds (and more site-specific data become available). The USEPA will then review and approve these deliverables, culminating in the *Final Design Reports* that provide detailed plans and specifications at a level that allows for bidding of the contracts by the RA lead party.

Another important project constraint on contracting approaches is the result of the magnitude and potential cost of the project. This dredging project will be one of the largest and most costly cleanup projects ever undertaken under the federal Superfund program. It is imperative that competitive bidding occur not only to provide a competent contractor, but also to provide for a competitive marketplace. The combination of the need for detailed design specifications, USEPA review, and approval and true market place competition limits the use of certain contracting approaches. For instance, design-build contracts (contract with a single firm to design, construct, and execute the remedy) will not likely be employed due to the need for USEPA approval of detailed design specifications and the need to competitively contract for the approved designs. The following will influence the development of the RA contracting approach:

- Detailed design specifications and RA contracts will be developed to support RA contracting.
- Prior to bidding, all design specifications will be approved by the USEPA.
- All RA contracts should be competitively bid.
- Pre-qualifications of bidders by the RA lead can occur prior to finalization of bid specifications.

At this point, it is not clear how contracting for Phase 1 and Phase 2 will be coordinated by the RA lead, since the final bid specifications for Phase 2 of the project will not be known at the time that Phase 1 of the project is expected to be bid. Also, it is uncertain what changes in the design for Phase 2 will be required after the results of Phase 1 are evaluated and peer reviewed. Given the unprecedented nature of the project, it is not unreasonable to expect substantive design changes between Phase 1 and Phase 2 that relate to material terms of the RA contract to perform the work. This will be discussed further in the *Phase 1* and *Phase 2 Intermediate Design Reports*.

Some of the contracting approaches likely to be considered by the RA lead may include:

- Single prime;
- Multiple prime contracts;
- Construction manager; and
- Combinations of formats.

A brief description of each contracting alternative is provided below.

Single Prime

Under this contracting approach, one RA contract document would be prepared for all the work and issued for bidding. All construction work would be conducted by one Prime Contractor utilizing its core competencies and supplementing specialty work through the use of subcontractors.

The advantages of the single prime contract include:

- Requires single Prime Contractor to assume responsibility for all construction coordination issues; and
- Provides one entity that is responsible for executing the work and allows negotiation of a single construction contract with Prime Contractor.

The disadvantages of the single prime contract include:

- Incurs costs for Prime Contractor markups on subcontractors and managing additional risks;
- May limit involvement of specialty contractors;
- May limit ability to assemble the best project team; and
- May limit number of potential contractors that participate in bidding process due to financial abilities (e.g., bonding, insurance) and resource requirements.

Multiple Primes/Contracts

Under this contracting approach, multiple RA contracts and bid package sets would be prepared, with each set geared towards core project elements and work tasks. Two or more contracting firms would then be employed, with each responsible for specified work. As an example, the project could combine project elements as follows: transportation and disposal; dredging and barging; on-shore processing. The entity (RA lead or construction manager) that has overall responsibility for the project would be responsible for administering the contracts with each of the separate prime contractors.

The advantages of the multiple primes/contract approach include:

- Allows overall responsible entity to select optimum specialty contractors;
- Allows for preparation of contract documents and bidding in sequenced phases;
- Allows for issuing and commencing contract work in sequenced phases to meet performance criteria and adjust for performance criteria modifications;
- Provides larger contracting pool to draw from for bidding; and
- Minimizes use of tiered subcontractors, lowering overall costs.

The disadvantages of the multiple primes/contract approach include:

- Requires additional management and coordination among the contractors;
- Places additional contract administration and management responsibility on overall RA responsible entity (e.g., contractor invoicing, scheduling etc.);
- Requires definitive scopes of work in each contract document; and
- Has potential for conflicts between prime contractors over responsibilities, schedule and costs.

Construction Manager

Under this contracting approach, similar to multiple primes/contracts, multiple contracts and bid package sets would be prepared, again with each set geared towards core project elements and work tasks. However, a

Construction Manager, on behalf of the overall RA lead, would issue the bid packages, receive the bids, recommend contract awards, and manage execution of the contract work.

The advantages of the Construction Manager approach include:

- Relieves the overall RA responsible entity from contract administration duties;
- Allows the RA overall responsible entity to select optimum specialty contractors (utilizing the experience of the Construction Manager);
- Allows for preparation of contract documents and bidding in sequenced phases;
- Allows for issuing and commencing contract work in sequenced phases to meet performance criteria and adjust for performance criteria modifications;
- Provides larger contracting pool for bidding; and
- Minimizes use of tiered subcontractors lowering overall costs.

The disadvantages of the Construction Manager approach include:

- Involves in-depth search to find firm with right expertise; and
- Incurs additional cost.

Combination of Approaches

A combination of the RA contracting approaches and strategies discussed above may prove to be the most effective approach for the Hudson River project. This approach will be explored further during the Phase 1 and Phase 2 Intermediate Design stages.

Each of the possible overall RA contracting approaches will be retained for further consideration in the Phase 1 and Phase 2 Intermediate Designs.

14.3 Preliminary Construction Specifications

Given the uncertainty that exists at this Preliminary Design stage, it is only possible to provide a preliminary list of contracting and construction specifications that may apply to this project. This list is provided in Appendix 14-A.

15. Value Engineering Scope

This section provides a preliminary scope for the Value Engineering work, as discussed in the RD Work Plan (BBL, 2003a). Value Engineering is a specialized cost control technique performed by an independent group of experienced professionals. The purpose of a Value Engineering Study is to achieve the best functional balance among cost, reliability, and performance of a product, process, system, or facility. A Value Engineering Study will be performed during the Phase 1 Intermediate Design and again during the Phase 2 Intermediate Design. Example project elements that may be evaluated by Value Engineering are:

- Design plans and specifications;
- In-river operations, sequencing, and coordination;
- Dredge area layouts and equipment selection;
- Resuspension control process options;
- Transport techniques for dredged material and backfill/cap material;
- Backfill/cap placement techniques;
- Shoreline stabilization/reconstruction and habitat replacement and reconstruction methods;
- Land-based material handling, dewatering, and water treatment methods; and
- Final loading, transportation, and disposal methods.

A successful Value Engineering Study involves the cooperative participation of three primary parties, the RD lead entity (GE), the project design team (BBL, et al.), and the Value Engineering Team Coordinator (VETC). The Value Engineering effort is divided into four sequential periods of activity: 1) qualification/bidding/contracting; 2) pre-design review; 3) Value Engineering meeting; and 4) post-Value Engineering (use of Value Engineering results). These periods and their application to the Hudson River project are described in sub-sections 15.2 through 15.5, below.

15.1 Value Engineering Team Members

The Value Engineering team members will be experienced in design, operation, and construction of sediment remediation projects. The team will be familiar with the principles of Value Engineering and construction operations to be used on the project. The technical experience of the Value Engineering team will primarily be in disciplines and engineering specialties most pertinent to the Hudson River project. It is too early to specify either the disciplines that will be represented on the Value Engineering team(s) or the number of team members; however, these will be decided during the Qualification/Bidding/Contracting period (see sub-section 15.2 below).

To provide support to the RD lead, the Value Engineering team will likely be supported by the VETC, an individual with extensive experience with Value Engineering.

The Value Engineering team(s) will be assembled by GE by either selecting individual members from different firms or all from a single firm. The Value Engineering team will not include any individuals from either the firms under contract to GE for preparing the engineering design, the firms under contract to the USEPA for any work related to the Hudson River PCBs Superfund Site, or the peer review panel for the Engineering Performance Standards.

15.2 Qualification/Bidding/Contracting

During this period, the qualifications of individuals and firms interested in providing Value Engineering services will be evaluated by GE. GE will then contract with the selected Value Engineering team members.

15.3 Pre-Design Review

During this period, the VETC will become familiar with the project, obtain and review design and cost information from GE and the design team, and work closely with GE to understand the project. The VETC will coordinate with a designated GE contact person and lead design person to complete logistical arrangements. The effectiveness of the Value Engineering meeting is ultimately dependent on 1) the Value Engineering team's understanding of the project and the project goals and constraints; and 2) the quality of the design and cost information made available.

15.4 Value Engineering Meeting

The Value Engineering team will review the available design and cost information prior to meeting with the RD team. The VETC will facilitate the discussion at any face to face meetings. Information will freely flow between the RD team and the VE team. An open and informed dialogue is critical to the success of the VE study.

Value Engineering meetings will last 40 hours and will culminate in an oral presentation of any VE meetings. Shortly after completion of the meeting, a written *Value Engineering Report* will be prepared by the VETC and submitted to GE.

15.5 Use of Value Engineering Results

Following the Value Engineering meeting, GE and the design team will review the Value Engineering report and decide whether to accept or reject each of the Value Engineering team's recommendations. GE will prepare a *Final Value Engineering Report* documenting the acceptance or rejection of each recommendation. This will conclude the post-workshop period. The *Final Value Engineering Report* will be included as part of the *Phase 1* and *Phase 2 Intermediate Design Reports*. Subsequently, GE and the design team will proceed to implement the accepted recommendations into the design.

15.6 Timing

Since design decisions have a large impact on the cost and success of a project, the highest return on the Value Engineering effort can be expected when Value Engineering efforts are performed early in the design before major decisions have been completely incorporated into the design. Accordingly, the first Value Engineering review will be scheduled to occur during the Phase 1 Intermediate Design stage.

Currently, a second Value Engineering Study is anticipated to be performed and concluded in a similar time-frame during the Phase 2 Intermediate Design stage. Following completion of the first Value Engineering Study and prior to scheduling a second study, GE will evaluate the following conditions:

- Whether going forward with a second Value Engineering Study appears justified based on anticipated benefits;
- Whether the timing of a second Value Engineering Study is appropriate for the Phase 2 Intermediate Design stage, or whether a different implementation time is potentially more beneficial; and
- Whether the same Value Engineering team that performed the first study should perform the second study, or whether different team members should be selected by GE.

16. References

Benford. 1991. Naval Architecture for Non-Naval Architects. The Society of Naval Architects and Marine Engineers, Jersey City, NJ.

BBL. 2003a. *Remedial Design Work Plan* (RD Work Plan). Hudson River PCBs Superfund Site. Prepared for General Electric Company, Albany, NY.

BBL. 2003b. *Supplemental Engineering Data Collection Work Plan* (SEDC Work Plan). Hudson River PCBs Superfund Site. Prepared for General Electric Company, Albany, NY.

BBL. 2003c. *Habitat Delineation and Assessment Work Plan* (HDA Work Plan). Hudson River PCBs Superfund Site. Prepared for General Electric Company, Albany, NY.

BBL. 2003d. *Treatability Studies Work Plan* (TS Work Plan). Hudson River PCBs Superfund Site. Prepared for General Electric Company, Albany, NY.

BBL. 2003e. *Revised Health and Safety Plan* (Revised HASP). Hudson River PCBs Superfund Site. Prepared for General Electric Company, Albany, NY.

BBL. 2003f. *Revised Community Health and Safety Plan* (Revised CHASP). Hudson River PCBs Superfund Site. Prepared for General Electric Company, Albany, NY.

Chanson, H. 2003. Rubber Dam Hydraulics: Hydraulic Design of Inflatable Flexible Membrane Dams http://www/uq.edu.au/~e2hchans/rubber/html.

City of Tacoma. 2003. *Thea Foss and Wheeler Osgood Waterways Remediation Project*, Work Order DC2001.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. *Classification of Wetlands and Deepwater Habitats of the United States*. U.S. Fish & Wildlife Service. FWS/OBS 79/31. Washington, D.C: U.S. Government Printing Office. http://www.npwrc.usgs.gov/resource/1999/sdwet/litcite.htm.

Cushing, B.S. and M.K. Hammaker. 2001. *Environmental Dredging: Methods, Trends, and Case Histories.* Proceedings of the Western Dredging Association, 21st Technical Conference, Houston, TX.

Cushing, B.S. 1999. "Identification and Evaluation of Remedial Dredging Difficulties." *Journal of Dredging Engineering*, July 1999.

Dow. 2002. *St. Clair River Dredging, Pilot Study Evaluation*. Prepared for Dow– Sarnia Remediation Team.

E&E. 2003. Database containing Geographic Information System Metafiles.

Elastec/American Marine. 2003. Website accessed at: www.elastec.com.

Ellicott. 2003. General Information for Hydraulic Dredges. Website accessed at: www.dredge.com/specs/dragon670.htm#productioncurve.

Environment Canada. 2003. Website accessed at: http://www.on.ec.gc.ca/pollution/ecnpd/pdf/collingwood.pdf.

EPRI. 1999. *Review of Sediment Removal and Remediation Technologies at MGP and Other Contaminated Sites*. EPRI, Palo Alto, CA, and Northeast Utilities, Berlin, CT: Final Report. TR-113106.

Esterline, R.C, J.B. Cange, and R.K. Lambert. 2002. *Dredging PCB-Contaminated Sediment from the St. Lawrence River: Project Overview.* Proceedings of the American Society of Civil Engineers, 3rd Specialty Conference on Dredging and Dredged Material Management, Orlando, FL.

Foster Wheeler. 2001. *Final Pre-Design Field Test Dredge Technology Evaluation Report*. New Bedford Harbor Superfund Site, New Bedford, MA.

GE. 2003. Major Contaminated Sediment Sites Database. Website accessed at: http://www.hudsoninformation.com/mcss/.

GE. 2000. *Environmental Dredging: An Evaluation of Its Effectiveness in Controlling Risks*. White paper prepared by BBL and AEM.

Gunderboom, Inc. 2003. Website accessed at: www.gunderboom.com.

Hammer & Steel, Inc. 2003. Website accessed at: www.hammersteel.com/hoesch.asp.

Hayes, D. F. 1998. *Sediment Resuspension by Selected Dredges.* Environmental Effects of Dredging, Technical Notes – EEDP-09-2, USACE.

Hayes, D.F. 1986. *Guide to Selecting a Dredge for Minimizing Resuspension of Sediment. Environmental Effects of Dredging*. Technical Note EEDP-09-1. USACE Waterways Experiment Station, Vicksburg, MS.

Hayes, D.F., T. Borrowman, and T. Welp. 2000. *Near Field Turbidity Observations During Boston Harbor Bucket Comparison Study*. Proceedings of the Western Dredging Association, 25th Technical Conference, Vancouver, WA.

Hayes, D.F., T.N. McLellan, and C.L. Truitt. 1988. *Demonstrations of Innovative and Conventional Dredging Equipment at Calumet Harbor, Illinois*. Miscellaneous Paper EL-88-1. USACE Waterways Experiment Station, Vicksburg, MS.

Herbich, J.B. 2000. *Handbook of Dredging Engineering. Second Edition*. New York, NY: McGraw-Hill, Inc.

Herbich, J.B. and S.B. Brahme. 1991. *Literature Review and Technical Evaluation of Sediment Resuspension During Dredging*. Contract Report No. HL-91-1, USACE Waterways Experiment Station, Vicksburg, MS.

Javeler Construction Co., Inc. 2003. Website accessed at: www.javeler.com.

Ken-Jet Corporation. 2003. Website accessed at: www.ken-jet.com.

Malcolm Pirnie, Inc. and TAMS Consultants, Inc. 2003. *Draft Engineering Performance Standards – Peer Review Copy.* Prepared for the USACE on behalf of the USEPA.

McGraw-Hill. 2001. *Handbook of Complex Environmental Remediation Problems, Chapter 4: An Evaluation of Environmental Dredging for Remediation of Contaminated Sediment.*

McLellan, T. and R. Hopman. 2000. *Innovations in Dredging Technology: Equipment, Operations, and Management*. ERDC TR-DOER-5. Prepared for the USACE.

Ministry of Environment. 2002. *Authorization for Works or Undertakings Affecting Fish Habitat*, 01HPAC-PA2-000-000470.

Mohan, R.K. 1998. *Remedial Dredging of Contaminated Rivers and Harbors – Challenges and Prospects*. Proceedings of the 15th World Dredging Conference, Las Vegas, NV.

Mohan, R.K. 1997. *Design and Construction of Subaqueous Caps for Restoring Contaminated Coastal Areas*. Proceedings of the ASCE Coastal Zone-97 Conference. Boston, MA.

NRC. 1997. *Contaminated Sediments in Ports and Waterways: Cleanup Strategies and Technologies.* Washington, D.C.: National Academy Press.

Normrock Industries, Inc. 2001. Technical Specifications. Website accessed: http://www.normrock.ca.

NYS Canal Corporation. 2003. Website accessed at: www.canals.state.ny.us/faq/index.html.

O'Brien & Gere, Inc. 1998. *1996 – 1997 Thompson Island Pool Studies*. February 1998.

Oehy, C. 2002. *Effects of Obstacles and Jets in Reservoir Sedimentation Due to Turbidity Currents*. Website accessed at: http://lchwww.epfl.ch/lch/recherhce/Oehy/fiche_e.htm.

Otis, M., S. Andon, and R. Bellmer. 1990. *New Bedford Harbor Superfund Pilot Study: Evaluation of Dredging and Dredged Material Disposal*. Prepared for USACE, New England Division.

Palermo, M.R., J.E. Clausness, M.P. Rollings, G.L. Williams, T.E. Myers, T.J. Fredette, and R.E. Randall. 1998a. *Guidance for Subaqueous Dredged Material Capping*. Technical Report DOER-1, USACE Waterways Experiment Station, Vicksburg, MS.

Palermo, M.R., S. Maynard, J. Miller, and D.D. Reible. 1998b. *Guidance for In-Situ Subaqueous Capping of Contaminated Sediments*. USEPA ARCS Program, EPA-905-B96-004.

Palermo, M.R., N.R. Francingues, and D.E. Averett. 2003. *Equipment Selection Factors for Environmental Dredging.* Proceedings of the Western Dredging Association, 23rd Technical Conference, Chicago, IL.

Parchure, T.M. 1996. *Equipment for Contaminated Sediment Dredging*. Technical Report HL-96-17. USACE, Waterways Experiment Station, Vicksburg, MS.

Parker Process Options. 2003. Website accessed at: www.parkersystemsinc.com.

PIANC. 1997. *Handling and Treatment of Contaminated Dredged Material from Ports and Inland Waterways: Volumes 1 and 2.* Report of Working Group No. 17. CD-ROM.

Pile Buck, Inc. 2003a. Website accessed at: www.PZ27.com/overview/interlock.html.

Pile Buck, Inc. 2003b. Website accessed at: www.pilespecs.com.

QEA. 2003. *Baseline Monitoring Program – Quality Assurance Project Plan* (BMP-QAPP). Hudson River PCBs Superfund Site. Prepared for General Electric Company, Albany, NY.

QEA. 2002a. *Sediment Sampling and Analysis Program – Field Sampling Plan* (SSAP-FSP). Hudson River PCBs Superfund Site. Prepared for General Electric Company, Albany, NY.

QEA. 2002b. *Sediment Sampling and Analysis Program – Health and Safety Plan* (SSAP-HASP). Hudson River PCBs Superfund Site. Prepared for General Electric Company, Albany, NY.

QEA and ESI. 2002. *Sediment Sampling and Analysis Program – Quality Assurance Project Plan* (SSAP-QAPP). Hudson River PCBs Superfund Site. Prepared for General Electric Company, Albany, NY.

Seawaytech. 2003. Website accessed at: www.seawaytech.com.

SEDTEC. 1994. *Environment Canada, "Directory of Contaminated Sediment Removal and Treatment Technologies"* CD-ROM.

Sevenson. 2003. Website accessed at: www.sevenson.com.

United States Department of Defense. 1999. *Unified Facilities Guide Specifications, Section 02457N, Steel Sheet Piles*, USACE/NAVFAC/AFCESA, Washington, DC.

URS. 2003. *Cultural and Archaeological Resources Assessment Work Plan* (CARA Work Plan). Hudson River PCBs Superfund Site. Prepared for General Electric Company, Albany, NY.

USACE. 2003a. Pacific Sound Resources Superfund Marine Sediment Unit Remedial Action. RFP No. DACW67-03-R-0003.

USACE. 2003b. *Evaluation of Dredged Material Proposed for Disposal at Island, Nearshore, or Upland Confined Disposal Facilities – Testing Manual* (Upland Testing Manual). ERDC/EL TR-03-1.

USACE. 1997. Engineering and Design - Handbook for the Preparation of Storm Water Pollution Prevention Plans for Construction Activities, BMP-27: Turbidity Curtains, EP 1110-1-16, February 1997.

USACE. 1990. Maintenance and Repair of Sheetpile Structures, Technical Report REMR-MO9.

USACE. 1983. *Dredging and Dredged Material Disposal, Engineer Manual*. EM 1110-2-5025.

USEPA. 2002a. *Hudson River PCBs Site - Record of Decision and Responsiveness Summary* (ROD). New York, NY. February 2002.

USEPA. 2002b. *Hudson River PCBs Superfund Site Facility Siting Concept Document* (Facility Siting Concept Document). New York, NY.

USEPA. 2000. *Hudson River PCBs Reassessment RI/FS Phase 3 Report: Feasibility Study* (FS). New York, NY. (December 2000).

USEPA. 1998. *Guidance for In-situu Subaqueous Capping of Contaminated Sediments.* Washington, DC.

USEPA. 1997. *Report on the Effects of the Hot Spot Dredging Operations*. New Bedford Harbor Superfund Site. New Bedford, MA.

USEPA. 1995a. *Guidance for Scoping the Remedial Design.* EPA 540/R-95/025. Washington, DC.

USEPA. 1995b. *Remedial Design/Remedial Action Handbook.* EPA 540/R-95/059. Washington, DC.

USEPA. 1994. *Assessment and Remediation of Contaminated Sediments (ARCS) Program Remediation Guidance Document*. EPA 905/R94-003. Great Lakes National Program Office, Chicago, IL (October 1994).

USEPA. 1990. *Guidance on USEPA Oversight of Remedial Designs and Remedial Actions Performed by Potentially Responsible Parties*. EPA 540/G-90/001. Washington, DC.

USEPA. 1987. *Handbook: Responding to Discharges of Sinking Hazardous Substances*. EPA 540/2-87-001., Washington, DC.

USEPA. 1984. *Removal and Mitigation of Sediment Contaminated with Hazardous Substances*. Preliminary Draft. Office of Research and Development. Cincinnati, OH.

USEPA/GE. 2003. Administrative Order on Consent for Hudson River Remedial Design and Cost Recovery (Index No. CERCLA-02-2003-2027) (RD AOC). Effective Date August 18, 2003.

USEPA/GE. 2002. Administrative Order on Consent for Hudson River Sediment Sampling (Index No. CERCLA-02-2002-2023) (Sediment Sampling AOC). Effective Date July 26, 2002.

USEPA/USACE. 1998. *Evaluation of Dredged Material Proposed For Discharge in Waters of the U.S. - Testing Manual* (Inland Testing Manual). EPA-823-B-98-004. Washington, DC.

USGS. 2000. *A Mass-Balance Approach for Assessing PCB Movement during Remediation of a PCB-Contaminated Deposit on the Fox River, Wisconsin*. USGS Water-Resources Investigation Report 00-4245.

Utilities (PacifiCorp Environmental Remediation Company and Puget Sound Energy). 2003. Head of Thea Foss Waterway Remediation Project.

Wang, T., K. Larm, and D. Hotchkiss. 2000. *Evaluation of Closed Buckets For Remedial Dredging and Case Histories,* Proceedings of the American Society of Civil Engineers, 3rd Specialty Conference on Dredging and Dredged Material Management, Orlando, FL.

Waterloo Barrier, Inc. 2003. Website accessed at: www.waterloo-barrier.com.

Wu, P.Y. and D.F. Hayes. 2000. *Verification and Enhancement of TSS Source Strength Models for Cutter Dredge*. Proceedings of the Western Dredging Association, 20th Conference Seminar. World Dredging, Mining and Construction.

17. Acronyms

% = percentage

21 NYCRR Part 151 = Title 21 of the *Official Compilation of the Rules and Regulations of the State of New York*, Part 151

AOC = Administrative Order on Consent

APE = Area of Potential Effect

ARARs = Applicable or Relevant and Appropriate Requirements

BBL = Blasland, Bouck & Lee, Inc.

BKRR = Batten Kill Railroad, Inc.

BMP-QAPP = *Baseline Monitoring Program – Quality Assurance Project Plan*

BUD = Beneficial Use Determination

CAA = Clean Air Act

CARA = cultural and archaeological resources assessment

CARA Work Plan = *Cultural and Archaeological Resources Assessment Work Plan*

CERCLA = Comprehensive Environmental Response, Compensation and Liability Act

CDF = confined disposal facility

cfs = cubic feet per second

CPR = Canadian Pacific Railway

CSXT = CSX Transportation Inc.

CU = certification unit

CWA = Clean Water Act

cy = cubic yards

DAD = dredge area delineation

DAD Report = *Dredge Area Delineation Report*

DGPS = differential global positioning system

DRET = Dredge Elutriate Tests

E&E = Ecology & Environment

EBCT = empty-bed contact time

ESA = Endangered Species Act

^{o}F = degrees Fahrenheit

Facility Siting Concept Document = *Hudson River PCBs Superfund Site Facility Siting Concept Document*

FCSs = Final Candidate Sites

FS = feasibility study

fps = feet per second

ft = feet

ft^2 = square feet

FTU = Formazin turbidity unit

FWPCA = Federal Water Pollution Control Act

g = gram

g/day = grams per day

g/m^2 = grams per square meter

GAC = granular-activated carbon

GE = General Electric Company

gpm = gallons per minute

GIS = geographic information system

GPS = global positioning system

GRS = Guilford Rail System

HDA = habitat delineation and assessment

HDA Work Plan = *Habitat Delineation and Assessment Work Plan*

HDPE = high-density polyethylene

hp = horsepower

HRFC = Hudson River Federal (Navigation) Channel

Inland Testing Manual = *Evaluation of Dredged Material Proposed For Discharge in Waters of the U.S. - Testing Manual*

IRM = interim remedial measure

kg = kilogram

kg/year = kilograms per year

KPV = key process variable

m = meters

Malcolm Pirnie and TAMS = Malcolm Pirnie, Inc. and TAMS Consultants, Inc.

MCSS = Major Contaminated Sediment Sites

mg/L = milligrams per liter

mg/kg = milligrams per kilogram

mgd = million gallons per day

mi^2 = square miles

MMF = multimedia filtration

MPA = mass per unit area

MSL = mean sea level

ng = nanogram

ng/L = nanograms per liter

NRC = National Research Council

NS = Norfolk Southern Railway

NSPS = New Source Performance Standards

NSR = Non-Attainment New Source Review

NTU = Nephelometric turbidity unit

NYS = New York State

NYS Canal Corporation = New York State Canal Corporation

NYSDEC = New York State Department of Environmental Conservation

OSI = Ocean Surveys, Inc.

P&IDs = piping and instrument diagrams

PCBs = polychlorinated biphenyls

PCSs = Preliminary Candidate Sites

PFDs = process flow diagrams

ppm = parts per million

processing facilities = sediment processing/transfer facilities

PSD = Prevention of Significant Deterioration

QEA = Quantitative Environmental Analysis, LLC

RA = remedial action

RA HASP = *Health and Safety Plan for Remedial Action*

RCRA = Resource Conservation and Recovery Act

RD = remedial design

RD AOC = Administrative Order on Consent for Hudson River Remedial Design and Cost Recovery

RD Work Plan = *Remedial Design Work Plan*

RM = River Mile

ROD = Record of Decision

SAV = submerged aquatic vegetation

SEDC = supplemental engineering data collection

SEDC Work Plan = *Supplemental Engineering Data Collection Work Plan*

Sediment Sampling AOC = Administrative Order on Consent for Hudson River Sediment Sampling and Analysis Program

SIP = State Implementation Plan

SOIs = Statements of Interest

SPDES = State Pollutant Discharge Elimination System

SPT = Standard Penetration Test

SSAP = sediment sampling and analysis program

SSAP-FSP = *Sediment Sampling and Analysis Program - Field Sampling Plan*

SWDA = Solid Waste Disposal Act

TCLP = toxicity characteristic leaching procedure

TOC = total organic carbon

Tornado = Tornado Motion Technology dredge

TSCA = Toxic Substances Control Act

TSS = total suspended solids

TS Work Plan = *Treatability Studies Work Plan*

Upland Testing Manual = *Evaluation of Dredged Material Proposed for Disposal at Island, Nearshore, or Upland Confined Disposal Facilities – Testing Manual*

Upper Hudson River = River Section 1, River Section 2, and River Section 3

USACE = United States Army Corps of Engineers

USEPA = United States Environmental Protection Agency

USGS = United States Geological Survey

VETC = Value Engineering Team Coordinator

w/w = weight/weight percentage