WORK PLAN

Habitat Delineation and Assessment Work Plan
Hudson River PCBs Superfund Site

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Albany, New York

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Table of Contents

Tables (Placed in text)

Figure

Attachments

1. Introduction

This *Habitat Delineation and Assessment Work Plan* (HDA Work Plan) has been prepared on behalf of the General Electric Company (GE) as part of the remedial design (RD) program for the remedy selected by the United States Environmental Protection Agency (USEPA) for the Upper Hudson River, located in New York State. Additional discussion of the RD program can be found in the *Remedial Design Work Plan* (RD Work Plan) (Blasland, Bouck & Lee, Inc. [BBL], 2003). Habitat delineation and assessment activities will be 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. This HDA Work Plan describes those habitat delineation and assessment tasks to be performed by GE to support the design of habitat replacement and reconstruction, which will be completed as part of the RD program for the Upper Hudson River. Habitat delineation and assessment tasks for the land-based sediment processing facilities and associated terrestrial access routes to the river are beyond the scope of this HDA Work Plan and will be conducted in accordance with the *Hudson River PCBs Superfund Site Facility Siting Concept Document* (Facility Siting Concept Document) (USEPA 2002a).

1.1 Site Background

On February 1, 2002, the USEPA issued a Superfund Record of Decision (ROD) that calls for the removal and disposal of approximately 2.65 million cubic yards of PCB-containing sediments (as estimated by the USEPA) from the Upper Hudson River (USEPA, 2002b).

In the ROD, the USEPA divided the Upper Hudson River into three sections (River Section 1, River Section 2, and River Section 3) (hereinafter referred to as the “Upper Hudson River”). The location of each section is described below and presented on Figure 1:

- **River Section 1:** Former location of Fort Edward Dam to Thompson Island Dam (approximately 6.3 miles);
- **River Section 2:** Thompson Island Dam to Northumberland Dam (approximately 5.1 miles); and
- **River Section 3:** Northumberland Dam to the Federal Dam at Troy (approximately 29.5 miles).

The Upper Hudson River ecosystem comprises a mosaic of habitat types, including submerged aquatic vegetation (SAV) beds, non-vegetated river bottoms, maintained and natural shorelines, and fringing wetlands.

The nature and extent of the specific habitats within this mosaic have changed through time due to the occurrence of natural and anthropogenic disturbances, such as major storms, dam installation and removal, shoreline and watershed development, lock construction and operation, and maintenance dredging. The removal of an estimated 2.65 million cubic yards of PCB-containing sediment is expected to change the river setting in some areas of the Upper Hudson River (e.g., deeper water). Thus, the locations and types of habitats in the Upper Hudson River may change from pre-dredging conditions, even after the habitat replacement and reconstruction work has been completed.

1.2 Goals of Habitat Replacement and Reconstruction Program

The USEPA’s 2002 ROD calls for dredging approximately 2.65 million cubic yards of sediments from the Upper Hudson River and backfilling of approximately 0.85 million cubic yards of clean material (USEPA, 2002b). It is important to establish goals for the habitat replacement and reconstruction program that acknowledge that the post-dredging environment of the Upper Hudson River will be different from the pre-dredging environment. The primary goal of the habitat replacement and reconstruction program is to replace the functions of the habitats of the Upper Hudson River to within the range of functions found in similar physical settings in the Upper Hudson River, in light of the changes in river hydrology, bathymetry, and geomorphology that will result from the implementation of the USEPA-selected remedy and from possible independent environmental changes that may occur from other factors.

The ROD (USEPA, 2002b) establishes certain requirements for the habitat replacement and reconstruction program for the areas of the river that will be disturbed by dredging:

- “A habitat replacement program will be implemented in an adaptive management framework to replace SAV communities, wetlands, and river bank habitat” (page A-3).

- “A shoreline stabilization program will be implemented” (page A-3).

- “If it is determined that the selected remedy requires unavoidable impacts to wetlands, EPA will implement compensatory wetland mitigation, as appropriate, in consultation with USACE, the federal trustees, and NYSDEC” (page A-3).

- “Riparian and shoreline stability will be maintained through determining the hydrology, sediment texture, and sediment stability of areas prior to initiating work” (page 9-10).

- “A detailed delineation of the Upper Hudson River habitats (including SAV), collection of baseline habitat data, and a wetland functional assessment will be conducted during remedial design. All available information, including the GE SAV report (Exponent, 1998), will be used in the delineation of Upper Hudson River habitats and collection of baseline habitat data. The detailed delineation of habitats and collection of baseline data will be used to formulate the habitat replacement program” (page 9-1).

The foundation for the habitat replacement and reconstruction program is adaptive management. In adaptive management, the goal of returning disturbed habitats to the desired range of functions is met by applying site-specific information in an iterative process of measurement and response (Holling, 1978). 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. The goals for adaptive management are met by falling within the range of attainable functions (minima to be considered “successful” and maxima that can be attained).

The overall objective of adaptive management is sustainability in landscapes affected by human development (Thom, 1996). Because ecosystems are complex and ecological processes are highly site-specific, effective management can only be realized by applying site-specific data to define goals and make management decisions (Haney and Power, 1996). This is particularly true for the Upper Hudson River, where ecological conditions, habitat sensitivity, and reconstruction attainability vary depending on specific environmental conditions at specific areas.

Success criteria for adaptive management at replacement and reconstruction sites are established via a range of habitat “bounds of expectation” (Weinstein et al., 1997). The bounds of expectation are established by measuring conditions in a range of areas that are not materially impacted by the project in question; these represent the natural (inherent) variation of the physical and structural elements for the ecosystem. In this approach, a range of values based on the physical limitations within the ecosystem are calculated, and are used to establish a “target” at which reconstruction or replacement activities are aimed. Bounds of expectation are best considered as the lower and upper confidence limits that encompass the mean of the sampled parameters. If a sample of a replaced or reconstructed habitat falls within the lower and upper confidence limits of unimpacted (reference) populations, that habitat is within the bounds of expectation.

In this case, as noted above, the overall goal of the habitat replacement and reconstruction program is to replace the functions of the Upper Hudson River habitats that are affected by the dredging to within the range of functions found in similar physical settings in the Upper Hudson River, given the changes in river conditions that will result from remedy implementation or from other factors. As discussed further below (Section 2.2.1), 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 program is to establish the range of such structural parameters in the Upper Hudson River habitats prior to dredging, which can be done by measuring these parameters both in areas that will be directly impacted by dredging and those that will not. 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 above objective. These design criteria will be included in the *Adaptive Management Plan*, which will be part of the *Final Design Report* for each phase of dredging.

However, to judge the success of the habitat replacement and reconstruction program after its implementation, given the changes in river hydrology, bathymetry, and geomorphology that may occur in the meantime (both from the dredging and from other, unrelated factors), areas within the Upper Hudson River that are not directly impacted by the dredging will be used as reference areas. Following remediation, these reference areas will exhibit the range of characteristics that will be obtainable for the habitats directly affected by the remedy, given the changes that have occurred in the meantime. Monitoring of the reference areas after the completion of the remediation will allow for modifications of the "bounds of expectation" for the structural parameters in the light of such changes. Thus, post-dredging comparisons of the structural parameters in the dredged areas to those in the reference areas will provide the primary basis for judging the success of the habitat replacement and reconstruction program. In addition, data being collected under other monitoring programs (e.g., flow data from the water column monitoring program and fish data from the fish monitoring program) will be used in the adaptive management program, where relevant, to augment the structural parameters being monitored and allow for early indication of success or potential problems. For example, if high flow is observed into the summer, correspondingly poor performance of reconstructed SAV habitat may be expected and may need to be considered in the timing or location of additional SAV reconstruction efforts.

In this context, the specific number and types of success criteria cannot be developed before the distribution and functions of the existing habitats are known and how impacted habitats will be replaced or reconstructed is determined. While the objective of the replacement/reconstruction program is to establish post-dredging habitats that fall within the bounds of expectation defined by conditions in similar non-dredged areas of the

Upper Hudson River, the specific post-reconstruction conditions for any particular site will ultimately be defined naturally by physical conditions at that site. This means that the objective for a specific site cannot be established *a priori* as either the "low end" or the "high end" of the range within the bounds of expectation. Rather, physical conditions at the site will determine where the post-dredging reconstructed/replaced habitat falls within the bounds. For the remediation area as a whole, it is to be expected that there will be a distribution of conditions in the replaced or reconstructed habitats that reflects the distribution of physical conditions in the river after dredging; some sites will fall high in the range, others will fall low. General narrative descriptions of success criteria will be provided in the *Adaptive Management Plan.* Specific numerical criteria will be developed when post-remediation monitoring is initiated, so as to take account of the then-existing conditions in the reference areas (and the pre-dredging conditions, as appropriate).

In addition to using comparisons to the structural parameters in the reference areas as the primary criteria to judge the success of the habitat replacement and reconstruction program, data that directly measure the relevant functions (e.g., presence and abundance of fish and/or wildlife species), to the extent available, will be used as success criteria in the event that the primary (structural) criteria are not met. Such functional criteria will not be used in the first instance to judge success – i.e., if the structural parameters in the dredged areas fall within the range of conditions in the reference areas, the habitat replacement/reconstruction will be considered successful, without further consideration of the functional criteria. However, if the structural parameters in the dredged areas do not fall within the range of conditions in the reference areas, the available functional data will be reviewed; and if the functional data (e.g., wildlife presence) fall within the range of those in the reference areas, the habitat replacement/reconstruction will be considered successful. (Note that, for these purposes, functions that are listed as measured variables in Table 2 are considered part of the primary criteria.)

In either case, it should be noted that although the habitat replacement/reconstruction efforts may incidentally improve structural or functional attributes of the dredged areas (over current conditions), the goal of the habitat replacement/reconstruction program is not to improve conditions, but to replace the functions of the impacted Upper Hudson River habitats (as measured either through structural parameters or through direct functional data) to within the range in non-impacted areas. Thus, the success criteria will be based on that goal and will not include improvements as an objective.

To achieve these goals and meet the requirements of the ROD, it is critical, at the outset, to develop and implement a technical approach for delineating and assessing baseline (pre-dredging) habitats in the Upper

Hudson River. Activities for delineating and assessing habitats in the Upper Hudson River are described in this HDA Work Plan.

In addition to the delineation and assessment of habitats, this plan describes the steps that will be taken to evaluate the potential impact of the selected remedy on threatened and/or endangered species (see Section 3 of this Work Plan).

The activities described in this HDA Work Plan are specific to the delineation and assessment of the Upper Hudson River habitats that may be impacted by dredging operations. As noted above, delineation and assessment of habitats that may be affected by the land-based sediment processing facilities and associated terrestrial routes to the river are beyond the scope of this Work Plan and will be conducted in accordance with the Facility Siting Concept Document (USEPA, 2002a). Potential wetland mitigation measures (if needed) related to land-based sediment processing facilities and associated terrestrial routes will be described in the Intermediate and Final Design Reports.

1.3 Goals of Habitat Delineation and Assessment

Consistent with the overall habitat replacement and reconstruction program, the goals of the habitat delineation and assessment activities are to:

- Document the nature and distribution of habitats potentially affected by remediation;
- Identify reference habitat locations representing the range (i.e., distribution) of existing conditions; and
- Identify measures of structure which are related to ecological function and hence are appropriate for use to determine when post-remediation habitat conditions fall within the ranges of reference conditions.

This HDA Work Plan presents the overall framework and identifies the technical approach that will be used to conduct the habitat delineation and assessment work. The technical approach described herein will be used to develop a baseline of information on the types, distribution, and functions of the habitats that are now present in the Upper Hudson River. To quantify the range of functions within the Upper Hudson River habitats, the assessment procedures focus on direct measurements of the physical structure of the habitats. There are several reasons for this strategy: (1) structural parameters are most commonly used to show success of restoration projects; (2) many functions can be inferred from structural measures; (3) structural parameters are less variable and are more reliably measured than most functional parameters; and (4) physical structural parameters are the variables that can reasonably be designed, manipulated, and managed as part of the habitat restoration/replacement program. The approach is tied to other elements of the RD program, as are the actual design efforts for habitat reconstruction and replacement (refer to the RD Work Plan for more details [BBL, 2003]).

1.4 Approach to Habitat Delineation and Assessment

1.4.1 Information and Data Quality Objectives

As noted above, the overall approach to habitat delineation and assessment is to obtain information on the existing physical structure of the habitats in the river, and associated ecological functions, to be used as the basis for establishing design criteria for the habitat replacement and reconstruction program. For example, the functions provided by the SAV beds in the Upper Hudson River are associated with a range of characteristics such as plant species diversity, stem densities, and individual shoot condition (i.e., length and thickness). Habitat replacement and reconstruction objectives for SAV beds will be defined by this range of structural characteristics (i.e., post-reconstruction SAV beds will be expected to fall within the range of structural characteristics and associated ecological functions found in the Upper Hudson River reference locations, taking into account any natural changes that have occurred in the meantime. In these circumstances, the key data quality objective (DQO) for the habitat delineation and assessment program is to define the range of habitat structure and associated ecological functions in the Upper Hudson River prior to implementing the USEPA-selected remedy. This DQO includes the following components:

1. Determine the location and extent of existing habitat types within the 40-mile river section where remediation is proposed, and at suitable reference locations in the Upper Hudson River.
2. Determine the range of structural parameters that are relevant to and associated with ecological functions within each habitat type.
3. Define the relationships between selected structural parameters and ecological functions within each habitat type.
4. Develop a database of habitat-specific data to facilitate subsequent identification and establishment of design criteria, success criteria, and long-term monitoring requirements for the habitat replacement and reconstruction program.

Meeting this DQO requires the collection of three basic categories of information:

- **Category 1:** Distribution of habitats in the project area;
- **Category 2:** Range of structural parameters and associated ecological functions in the Upper Hudson River as a whole; and
- **Category 3:** The "footprint" of sediment removal activities, as specified in the *Dredge Area Delineation Reports,* which will impact existing habitats.

This HDA Work Plan addresses Categories 1 and 2. Category 3 information will be obtained through the Sediment Sampling and Analysis Program (SSAP) being conducted pursuant to the Administrative Order on Consent for Sediment Sampling (hereafter referred to as the "Sediment Sampling AOC"), which became effective on July 26, 2002 (Index No. CERCLA 02-2002-2023) (USEPA, 2002c), and the dredge area delineation activities to be conducted as part of remedial design, as well as the habitat assessment activities.

1.4.2 Overview of Habitat Delineation and Assessment

The habitat delineation and assessment program involves two types of activities, which will be conducted sequentially: general habitat delineation and habitat assessment.

1.4.2.1 Habitat Delineation and Classification

Three major habitat types are present within the Upper Hudson River: river bottom, shoreline, and fringing wetland habitats. Field investigations and data review will provide the basis for habitat classification (following the general approach of Cowardin et al., 1979), to produce habitat maps for the Upper Hudson River. Boundaries of the habitats delineated from aerial photography, ground-truthing and field surveys will be mapped. These activities will be completed following USEPA approval of this HDA Work Plan and execution of an Administrative Order on Consent for RD (hereafter referred to as the "RD AOC"). It is anticipated that these activities will be completed during the Year 2 field season of the SSAP. The resulting maps will be compiled and submitted in the *Habitat Delineation Report* (as described in the RD Work Plan [BBL, 2003]). A subset of areas will be spot-checked in subsequent years to assess fluctuations in size and location of habitat types, particularly SAV beds.

1.4.2.2 Habitat Assessment

The ecological functions of the habitat areas that are likely to be directly affected by dredging activities will be evaluated in detail. Habitat assessments will be conducted for representative areas within each habitat type both in areas subject to or directly affected by the remediation and in reference areas that will not be affected by the remediation, and will focus on measurable ecological structural parameters that determine the biological and physical functions of each habitat type. For example, the assessment parameters for SAV beds within the river bottom will include plant species diversity, stem density, percent cover, and biomass.

As described in the RD Work Plan (BBL, 2003), habitat assessments will be conducted separately for: (1) the areas that are candidates for Phase 1 of the dredging program (as identified in the RD Work Plan); and (2) the remaining dredge areas, covered by the *Dredge Area Delineation Report* for Year 2 of the SSAP (hereinafter "*Year 2 Dredge Area Delineation Report*"). For the candidate Phase 1 areas, the habitat assessments will be conducted during the Year 2 field season in conjunction with or immediately after the habitat delineation and classification work for those areas. For the remaining areas to be dredged, the habitat assessments will be conducted during the next field season, following USEPA approval of the *Year 2 Dredge Area Delineation Report*. In addition, a subset of dredge and reference areas assessed during each of these field seasons will be spot-checked and reassessed if necessary in subsequent years to assess fluctuations in size or location of habitat types, particularly SAV beds. This subsequent spot checking for variability will include areas assessed during both years of the HDA work.

Detailed protocols for these habitat assessments are provided in Attachments A through D to this HDA Work Plan, and are based on existing data, including preliminary SAV habitat data collected during the summer of 2002 (Exhibit B-1 to Attachment B). The results of the habitat assessments will be presented in separate *Habitat Assessment Reports* – one for the candidate Phase 1 areas and one for the remaining dredge areas covered by the *Year 2 Dredge Area Delineation Report.*

1.5 Format of HDA Work Plan

The remainder of this HDA Work Plan consists of the following four sections:

- Section 2 describes the habitat delineation, classification, and assessment activities to be conducted.

- Section 3 describes the biological assessments (BAs) that will be performed for the two principal threatened or endangered species that have been identified by the USEPA as possibly affected by dredging activities – the bald eagle and the shortnose sturgeon.
- Section 4 presents the schedule for conducting the activities to be performed under this HDA Work Plan, including the relationship of these activities to the other RD activities described in the RD Work Plan (BBL, 2003).
- Section 5 contains references used to prepare this HDA Work Plan.

In addition, Standard Operating Procedures (SOPs) that describe habitat assessment methodologies are presented as separate attachments to this HDA Work Plan.

2. Habitat Delineation and Assessment

As noted above, the overall approach to habitat delineation and assessment will involve: (1) habitat delineation and classification; and (2) habitat assessments. These activities will be conducted for each of the three primary habitat types within the Upper Hudson River ecosystem:

1. **River Bottom Habitats:** Both unconsolidated river bottom and aquatic vegetation beds;
2. **Shoreline Habitats:** Maintained (delineation) and natural (delineation and assessment) shorelines; and
3. **Wetland Habitats:** Fringing wetlands.

This section describes the habitat delineation and assessment efforts to be performed for these habitats.

2.1 Habitat Delineation and Classification

2.1.1 General

The habitat assessment program outlined in this HDA Work Plan includes, as a first step, delineating and classifying habitats in the Upper Hudson River. Habitat information will be compiled to produce habitat delineation maps that document the distribution (areal extent) and type (classification) of habitats in the Upper Hudson River prior to remediation activities. Habitat delineation maps will be used as a foundation for the following activities:

- Overlaying dredging footprints;
- Identifying habitats directly affected by dredging; and
- Identifying habitat types and reference areas for habitat assessments.

Development of the habitat delineation maps for the Upper Hudson River will require a review of historical data (e.g., existing aerial photographs, photogrammetric maps, United States Geological Survey [USGS] maps, National Wetland Inventory [NWI] Maps, New York State Department of Environmental Conservation [NYSDEC] wetland maps, Federal Emergency Management Agency [FEMA] maps, and soil surveys), identification of data gaps, and collection of additional data for habitat delineation and classification. There are two primary data collection methods that will be used to complete the habitat delineation and classification, and thus to produce the comprehensive base maps of habitats. The first consists of the side-scan sonar surveys that are already in progress as part of the SSAP that is being conducted pursuant to the SSAP-Field Sampling Plan (SSAP-FSP) (QEA, 2002) and the Sediment Sampling AOC (USEPA, 2002c). The second consists of aerial photography. Existing aerial photographs and maps will be used to the greatest possible degree. This information will be supplemented by additional aerial photographs taken specifically to support this habitat delineation effort. The habitat types identified through the review of existing information and aerial photography will then be ground-truthed through field observations in representative areas within each habitat type to verify the accuracy and precision of the photo interpretation effort and (where relevant) to identify dominant plant species. The collected information will be integrated into a comprehensive geographic information system (GIS) database from which the habitat maps will be produced. (Note that SAV beds in the Lower Hudson River are being mapped by NYSDEC and the Hudson River National Estuarine Research Reserve. However, this SAV mapping effort for the Lower Hudson is a separate program and will not be incorporated into the GIS database.)

Table 1 (below) summarizes the habitat types, activities to be performed in delineating and classifying such habitats, and procedures necessary to complete the activities.

Table 1 – Summary of Work Items to be completed for Habitat Delineation and Classification

Habitat Types	Activity	Procedures
Unconsolidated River Bottom (Non-Vegetated River Bottom)	Assess habitat characteristics using side-scan sonar and sediment sampling from SSAP	▪ Side-scan sonar and sediment coring work (SSAP-FSP) (QEA, 2002) ▪ Ground-truth in representative areas
Aquatic Beds (Vegetated River Bottom)	Delineate SAV beds from vertical aerial photography, as well as side-scan sonar and substrate characterization data from SSAP	▪ Review existing information ▪ Side-scan sonar and sediment coring work (SSAP-FSP) (QEA, 2002) ▪ Obtain and interpret photos ▪ Ground-truth in representative areas
Shoreline	Identify maintained and natural shoreline habitats from oblique aerial photography	▪ Review existing information ▪ Obtain and interpret photos ▪ Ground-truth in representative areas
Wetlands	Delineate fringing wetlands from vertical and oblique aerial photographs	▪ Review existing information ▪ Obtain and interpret photos ▪ Ground-truth in representative areas

The following sub-sections of this HDA Work Plan focus on activities for delineating and classifying each of these habitats. The resulting maps will be presented in the *Habitat Delineation Report*.

2.1.2 River Bottom Habitat

For this assessment, the river bottom can be separated into non-vegetated river bottom and aquatic vegetation bed habitat. Dredging both of these types of habitats is expected as part of the USEPA-selected remedy. The delineation of these habitats within each River Section prior to remediation will be used to document the nature and extent of habitat types that will potentially be impacted.

2.1.2.1 Unconsolidated (Non-Vegetated) River Bottom

The nature of the unconsolidated river bottom substrate (e.g., organic, fines, sand, or cobble) and other submerged features (e.g., large boulders, debris, and fallen trees) will be determined through the side-scan sonar study (see the SSAP-FSP [QEA, 2002]).

Using the side-scan sonar data, unconsolidated bottoms will be characterized based on the nature and extent of substrate type and other submerged features (e.g., large boulders, debris, and fallen trees), where present. These features will be identified through a combination of side-scan image interpretation and ground-truthing.

As stated in the SSAP-FSP (QEA, 2002), the side-scan sonar data will be ground-truthed during the SSAP investigations. Substrate data will be used to develop maps for the primary purpose of the sediment sampling program; however, these maps will also serve as information for the habitat delineation. Maps and any other observations or interpretations recorded during side-scan operations will be provided to project scientists so that unconsolidated river bottom habitats can be delineated.

2.1.2.2 Aquatic Vegetation Bed

Aquatic beds are river bottom habitats where SAV is present. Some information on aquatic vegetation bed habitats was presented as part of previous river investigations, with the most recent information on SAV delineation collected by GE in 1997 (Exponent, 1998) and 2002 (Exhibit B-1). The 1998 Exponent report identifies several species of SAV that are common in shallow-water habitats of the Upper Hudson River. The occurrence of SAV and emergent vegetation in the Upper Hudson River was also surveyed in 1991 (Law Environmental, 1991). Existing data will be used to aid in delineating aquatic bed habitat. Methods for characterizing the nature and extent of aquatic beds include:

- Review of existing information;
- Vertical aerial photography;
- Side-scan sonar data; and
- Ground-truthing/field observations in representative areas.

Vertical aerial photography will be the primary method for delineating SAV. New aerial photographs of the Upper Hudson River will be taken specifically to support this habitat delineation effort in general accordance with the procedures outlined in *Guidance for Benthic Habitat Mapping: An Aerial Photographic Approach* (National Oceanic and Atmospheric Administration [NOAA], 2001) during the period of peak SAV biomass, which, for the Upper Hudson River, is typically in July. After the review of existing data and new aerial photographs is completed, the extent of the aquatic beds will be preliminarily digitized for incorporation into the GIS database, and maps showing the locations of these habitats on the aerial photographs will be produced. These maps will be used in the field for ground-truthing during the same year that aerials are flown, and before plant senescence, to verify the accuracy and precision of the photo interpretation effort.

Image acquisition protocols include:

- Color negative film;
- Flight lines with a minimum 30% sidelap and 60% endlap will be used to obtain stereoscopic images;
- 1” = 200’ scale;
- No substantial rainfall or wind events within 48 hours of image acquisition;
- 30- to 45-degree sun angle; and
- Less than 5% cloud cover.

The NOAA (2001) Guidelines for photo interpretation and image analysis include:

- Use of high-quality stereoscopic instruments;
- Photo interpreters with prior experience delineating aquatic vegetation beds;
- Image resolution of the deep edge of the bed;

- Application of the adapted crown-density scale (Orth et al., 1991); and
- Field survey/ground-truthing in representative areas.

Vertical aerial photographs of the Upper Hudson River will be provided to experienced photo interpreters so aquatic bed habitats can be identified and delineated. The guidelines used in this interpretation will be fully described in the *Habitat Delineation Report*. The boundaries for all identified SAV beds will be delineated through photo interpretation, and representative areas will be ground-truthed to verify accuracy of the photo interpretation and to identify the various types of SAV beds. All identified SAV beds will be incorporated into the GIS database and mapped following ground-truthing. Ground-truthing will be used to field-verify the presence of aquatic beds within the season (July through September) in which the photographs were taken.

Ground-truthing of the aquatic vegetation bed habitat observed on the vertical aerial photographs will be conducted by boat. Ground-truthing efforts will be concentrated in River Sections 1 and 2, with a lower level of effort in River Section 3, generally proportional to the dredging planned. Scientists will have preliminarily identified locations on the aerial photographs where SAV are expected to be present. The photographs will be brought into the field, and areas preliminarily identified as containing SAV will be located by the boat. Once located, scientists on the boat will record information that: (1) confirms the presence, size, and global-positioning system (GPS) coordinates of the aquatic beds; (2) documents SAV species that are present; and (3) quantitatively estimates the relative abundance of each SAV species. This information will be recorded in a field logbook.

Once project scientists have identified the location, type, and size of SAV habitats, this information will be incorporated into the GIS database. The location, type, and size of aquatic beds in the Upper Hudson River will be shown on maps.

2.1.3 Shoreline Habitats

Habitat along the terrestrial edge of the river is often referred to as riparian or shoreline habitat. Shoreline habitat types within the assessment area can be grouped into two major categories: maintained or natural (i.e., unconsolidated shore, as defined by Cowardin et al., 1979). Maintained shoreline includes areas where residential lawns and commercial and industrial properties have stabilized the shoreline with riprap, bulkhead piling, or concrete. Natural shorelines comprise a diversity of non-vegetated and vegetated habitat types.

Delineation of shoreline habitats prior to remediation will be conducted in the Upper Hudson River to document the nature and extent of habitat types that exist. The methods for characterizing the nature and extent of shoreline habitats include:

- Review of existing information;
- Oblique aerial photography; and
- Ground-truthing/field observations in representative areas.

Oblique aerial photography will be the primary method from which shoreline habitats will be documented. The use of oblique aerial photography will facilitate identification and delineation of natural shoreline and near-shore features that would be obstructed on vertical photographs due to the presence of trees and shrubs along the shoreline (Paine, 1981). A low-flying aircraft (1,000 feet or less) will fly along the Upper Hudson River and record shoreline features using a high-resolution camera. (This effort is anticipated to be conducted in July 2003 following execution of the RD AOC.) Each of the photographs will be examined to delineate the shoreline as maintained or natural. After the review of existing data and the new oblique aerial photographs is completed, the approximate extent of shoreline habitat types will be preliminarily digitized for incorporation into the GIS database, and maps showing the locations of shoreline types will be produced. These maps will be brought into the field for ground-truthing to verify the accuracy and precision of the photo interpretation effort. In addition, for natural shoreline areas, adjacent areas will be qualitatively categorized into different landscapes (e.g., agricultural land, grassland, floodplain, forested, emergent wetland, etc.) and the width of the riparian zone determined to the extent allowed by the photography. Maintained shoreline areas will be categorized into types (e.g., riprap, bulkhead piling, concrete).

Image acquisition protocols include:

- Color negative film;
- Flight lines with appropriate overlap;
- Appropriate scale (1” = 200’ to 500’);
- No substantial rainfall or wind events within 48 hours of image acquisition;
- 30- to 45-degree sun angle; and
- Less than 5% cloud cover.

The NOAA (2001) Guidelines for photo interpretation and image analysis, using high-quality stereoscopic instruments, will be employed.

Ground-truthing of representative shoreline habitats will be documented using video photography to verify the results of the photo interpretation. Ground-truthing efforts will be concentrated in River Sections 1 and 2, with a lower level of effort in River Section 3, generally proportional to the dredging planned. The locations of shoreline habitats will be identified, categorized by vegetation type, and mapped.

2.1.4 Wetland Habitats

The wetlands within the Upper Hudson River that are most likely to be directly affected by dredging activities (if there are impacts on wetlands) are fringing (shoreline) wetlands, a single subclass in the riverine hyrdogeomorphic class. As a result, this section focuses on the delineation of these types of wetlands. In the event that wetlands from other riverine hydrogeomorphic subclasses (e.g., sheltered) are identified as being directly impacted by dredging, those wetlands will be delineated consistent with the procedures discussed below for fringing wetlands. Dredging will not impact other types of wetlands (connected forested, isolated emergent, and isolated forested) because they are outside the banks of the river. If these other wetland habitats will be impacted by the sediment processing and transfer facilities, they will be evaluated during land-based processing facility siting activities consistent with the Facility Siting Concept Document (USEPA, 2002a).

Fringing wetland habitats/delineation will be based on:

- Available aerial photographs (vertical or oblique);
- Existing site maps;
- Review of existing information (reports);
- USGS topographic maps;
- NWI maps;
- NYSDEC wetland maps;
- FEMA maps;
- Soil surveys; and
- Ground-truthing/field observations in representative areas.

Fringing wetland habitats within the Upper Hudson River will be delineated based on all available information. The boundaries for all identified fringing wetland habitats will be delineated through photo interpretation (as will the boundaries for backwater wetlands, to the extent allowed by the aerial photography), and representative areas will be ground-truthed to verify accuracy of the photo interpretation and to identify dominant plant species. The delineated fringing wetland areas will then be digitized for incorporation into the GIS database, and maps showing the locations of fringing wetlands will be produced. These maps will be used in the field for ground-truthing. Ground-truthing efforts will be concentrated in River Sections 1 and 2, with a lower level of effort in River Section 3, generally proportional to the dredging planned.

The location and extent of the wetlands will be documented in the field by comparing field observations with information on aerial photographs or other wetland maps such as those described above. As fringing wetland habitats are confirmed, these locations will be documented in the GIS database and mapped.

Wetlands that will be directly impacted by remediation activities (and reference wetlands) will be delineated in accordance with the 1987 United States Army Corps of Engineers (USACE) *Wetland Delineation Manual*. Field investigations will be conducted and areas identified as wetlands (using the three-parameter approach) will be flagged and surveyed (USACE, 1987). Delineated wetland boundaries will be incorporated in the GIS database, and photo documentation and field data forms will be completed**.**

2.2 Habitat Assessment

2.2.1 General Approach

Following completion of the habitat delineations and classifications, habitat assessments will be conducted in representative areas for each type of habitat. These areas will include both target or assessment areas and reference areas. Target areas will be located within portions of the Upper Hudson River that have been determined or are expected to be directly affected by dredging, with an effort to include a full range of structural parameters for the type of habitat in question. Reference areas will be selected for each habitat type from within each section of the river (River Sections 1 through 3). These reference areas will consist of habitats that are not expected to be directly affected by dredging and will represent a full range of structural parameters for the habitat type. Reference areas will be identified from a review of aerial photographs, maps, field surveys, and other available information. The purpose and selection of reference areas are discussed further in Section 2.2.1.1.

Some common features of large river systems that are important for environmental assessment include:

- River bottom type (Platts et al., 1983);
- Shoreline type (Schuytema, 1982); and
- Wetlands type (Casselman and Lewis, 1996; Brazner and Magnuson, 1994).

These features provide structural "complexity" to river habitat for aquatic communities. In general, where there is suitable habitat structure, aquatic communities and associated ecosystem functions are present. As an example, fish are both common and abundant in SAV, which is a type of structure, but are not as common or abundant in areas where no SAV is present, such as along unconsolidated, featureless bottoms.

The habitat assessments to be conducted in the four habitat types will rely mainly on field investigations and will focus primarily on direct measurements of the physical structure of the habitats, which will serve as a foundation to quantify ecological functions. The reasons for using measurements of structural parameters to quantify functions are explained in Section 1.3. This concept is one of the foundations of several widely used or supported habitat evaluation procedures, including the hydrogeomorphic (HGM) assessment method (Ainslie et al., 1999; Smith and Kilmas, 2002; Shafer et al., 2002) and Habitat Suitability Indices (HSIs), and is supported by a variety of references (e.g., Fonseca et al., 2002; Niedowski, 2000). Indeed, habitat replacement and reconstruction programs must, of necessity, focus on structural parameters that can be managed or manipulated.

The relevant functions and associated structural measurement variables for each habitat type are summarized in Table 2, along with a brief rationale for the selection of each measurement variable (i.e., how it relates to the listed function). The relationships between these functions and the associated measurement variables are discussed in more detail in the following sections of this HDA Work Plan. Those sections describe, for each habitat, how habitat structure determines ecological function (e.g., the relationship of aquatic communities to the habitat), and present the characterization tasks that will be used to document existing structural characteristics of Upper Hudson River habitats and how the structural characteristics correlate to function. Some functions (e.g., macrophyte primary production in aquatic beds) will develop more quickly than others (e.g., water quality enhancement in aquatic beds). Temporal considerations for the functional development will be addressed, to the extent necessary, in the *Adaptive Management Plan*. The specific protocols and scope for conducting the functional assessments of the habitats outlined in Table 2 are provided in Attachments A through D of this HDA Work Plan.

For the candidate Phase 1 areas, the habitat assessments will be conducted in the same field season as the habitat delineation work. Habitat assessment information will be used to develop habitat-specific design criteria for the habitat reconstruction or replacement program and recovery criteria for use in the adaptive management program. The specific assessment (target) areas and reference habitat locations for these dredging areas will be identified immediately following the habitat delineation efforts for these portions of the Upper Hudson River and will be reported in the *Habitat Delineation Report*. For the dredging areas covered by the *Year 2 Dredge Area Delineation Report*, the habitat assessments will be conducted in the following field season, after USEPA approval of that *Dredge Area Delineation Report*. The specific assessment (target) areas and reference habitat locations for these dredge areas will be identified in the *Supplemental Engineering Data Collection Work Plan* for Year 3 (as described in the RD Work Plan [BBL, 2003]). In addition, a subset of dredge and reference areas assessed during each of these field seasons will be spot-checked and reassessed as necessary in subsequent years to assess fluctuations in size or location of habitat types, particularly SAV beds. This subsequent spot-checking for variability will include areas assessed during both years of the habitat assessment work.

Table 2 – Summary of Work Items to be Completed for Habitat Assessments

Function	Measured Variable	Rationale
UNCONSOLIDATED RIVER BOTTOM		
Potential to Support Macroinvertebrate Populations	Total organic carbon Substrate and cover Embeddedness Percent fines	Food resources for BMI Protection from predation; attachment Availability of cobble, gravel for attachment Burrowing substrate; related to TOC
Potential to Support Fish Populations	Substrate and cover Embeddeness Percent fines	Protection from predation; spawning substrate Availability of spawning substrate Related to embeddedness
AQUATIC BED		
Macrophyte Primary Productivity	Shoot biomass Percent cover	Represents productivity Areal extent of productivity for SAV bed
Support PMI/BMI Populations	Shoot biomass Shoot density Percent cover Plant species composition Light availability Water depth Current velocity	Represents available food resources for BMI/PMI Substrate for PMI settlement; dampens wave/current energy Protection from predation Plant architecture related to number of PMI Growth productivity of SAV and epiphytes Correlated to light availability Settlement of PMI; scouring of BMI habitat
Provide Habitat for Fish Populations	Shoot biomass Shoot density Percent cover Plant species composition	Represents available food resources for BMI/PMI Related to ease of movement within SAV bed Protection from predation; access to open water Meadow versus canopy species offer differing levels of protection / access
Stabilization of Substrate	Shoot density Percent cover Percent fines Current velocity	Dampens wave/current energy Areal extent of dampening effect Related to potential for resuspension of sediment Higher current scours or resuspends more sediment
Water Quality Enhancement	Shoot density Percent fines	Shoots dampen wave/current energy allow particles to settle out of suspension Related to potential for resuspension of sediment
Nutrient Cycling	Shoot biomass Percent fines Sediment nutrient availability	Standing crop of organic material Related to anaerobic conditions (allows denitrification); related to organic material in sediment Indicates availability of nutrients cycled from organic matter
SHORELINE		
Shoreline Stability	Downfall (trees/m2) Bank stability Bank vegetation protection	Large trees armor bank against scour Stable banks less likely to slump, fail Presence indicates longer term stability
Shade and Cover	Downfall (trees/m2) Bank vegetation protection Riparian edge cover	Provides in-water cover; organic food source Overstory provides shade, thermal cooling Cover for wildlife accessing shoreline
Wildlife Habitat (Habitat Suitability)	Downfall (trees/m2) Bank stability Bank vegetation protection Riparian edge cover	Provides in-water cover; organic food source Less open areas; ease of access to water Shade and cover for access Protection from predation between access points

Table 2 (cont'd) – Summary of Work Items to be Completed for Habitat Assessments

Function	Measured Variable	Rationale
	WETLANDS	
Energy Dissipation	Wetland area	Larger wetlands extend along longer shoreline
	Percent wetland edge altered	Intact wetlands buffer wave/current energy better
	Slope	Low slope relates to less reflected energy
	Stem density	Stems dampen wave/current energy
	Stem thickness	Sturdier plants withstand stronger flows
	Stem length	Taller plants protect during higher flows
	Above-ground biomass	Standing stock (or bulk) of material baffling Energy
Surface-Water Exchange	Wetland area	Indicates size of surface – water interface
	Presence/fluctuating water table	Indicates potential for infiltration to occur
	Slope	Lower slope relates to longer residence time
Primary Production	Wetland area	Areal extent of productivity
	Above-ground biomass	Shoot biomass surrogate for productivity
Nutrient Cycling	Above-ground biomass	Represents total mass of living organic matter available to enter nutrient cycle
	O Horizon - percent cover	Recognizable dead organic matter and associated decomposers
	A Horizon - percent cover	Unrecognizable dead organic matter entering nutrient cycle. Combined with "O" horizon, indicates nutrients are being recycled.
Remove and Hold Elements/ Compounds	Clay content	Clay particles have more binding sites for holding elements
	Redoximorphic features	Indicates that denitrification has occurred
	O Horizon - percent cover	Organic matter available for holding elements / compounds
	A Horizon - percent cover	Combined with "O" horizon, indicates organic matter available for holding elements / compounds
Export Organic Carbon	O Horizon - percent cover	Organic material in surface soil layer that can be readily exported
Maintain Character Plant Community	Plant species composition	Diverse communities more "stable"
	Stem density	Related to area open for colonization
	Above-ground biomass	Indicates relative productivity
Wildlife Habitat (Habitat Suitability)	Wetland area	Larger areas support larger communities
	Area of buffer	Allows greater isolation of wetland interior
	Contiguous with other habitats (percent)	Connectivity; emigration; increased foraging opportunities
	Plant species composition	Diverse plant communities can support higher diversity of wildlife
	Stem density	Cover, protection from predation
	Above-ground biomass	Related to primary productivity (food resources)

2.2.1.1 Reference Areas

As noted above, the goal of the habitat replacement and reconstruction program is to replace the functions of the Upper Hudson River habitats that are directly affected by dredging to within the range of functions found in similar physical settings in the Upper Hudson River that are not directly affected by the dredging, in light of the changes in river conditions that will result from implementation of the remedy or from other factors. To determine the current “range of functions” across all areas in the Upper Hudson River (which, as discussed above, will be assessed through measurements of the variables listed in Table 2), there is no need for a distinction between target and reference areas (i.e., all areas will be considered in developing the functional range). All areas to be assessed as part of HDA activities will provide pre-dredging information on the current range of structural parameters and thus associated functions. This information will be used for two purposes: first, to develop design criteria for the habitat replacement and reconstruction program and; second, to identify and assess reference areas to be used after dredging as discussed in the next paragraph.

The primary purpose for identifying and assessing reference areas prior to dredging is to identify those areas that, after dredging, will be used to evaluate the success of the habitat replacement and reconstruction program. During the dredging period, overall changes in river hydrology, bathymetry, and geomorphology may occur, not only from the dredging but also from unrelated factors that could affect habitat characteristics. These changes in the river could affect both the reference and dredged areas within the overall project area. Therefore, identifying reference areas prior to dredging considers such changes to the river to determine the habitat characteristics and conditions that are attainable following remediation. Monitoring of the reference areas after remediation will inform management decisions on how changes in river conditions potentially impact habitat structure and/or function. Accordingly, as noted above, post-dredging comparisons of the structural parameters in the dredged areas to those in the reference areas will provide the primary basis for judging the success of the habitat replacement and reconstruction program. For these purposes, the identification of reference areas that are located within River Sections 1, 2, and 3 but will not be directly impacted by the dredging provide the most appropriate reference areas to use, since they will best reflect other changes to the river in this area.

In addition, however, consideration will be given to using “off-site” reference areas – i.e., areas located upstream of the 40-mile project area or on the lower Mohawk River. These areas would not serve as a substitute for the use of reference areas within River Sections 1, 2, and 3 in evaluating habitat replacement/reconstruction success. Rather, the purpose for identifying and later using off-site reference areas would be to evaluate the impacts (if any) of potential broad, watershed-wide or regional changes that may extend beyond the 40-mile project area, and determine whether these changes have an effect on habitat replacement/reconstruction success. (Note that USEPA or GE may consider additional use of these data). To evaluate whether suitable off-site reference areas exist and, if so, to identify such areas, a two-step approach will be implemented.

Step 1 will involve review of existing information (such as aerial or digital photographs, photogrammetric maps, USGS topographic maps, NWI Maps, NYSDEC wetland maps, FEMA maps, and/or bathymetric or sediment surveys), as well as acquiring additional aerial photographs if necessary, to preliminarily identify potential locations of off-site reference areas. This review will focus on unconfined river areas, as defined by the New York Natural Heritage Program (Edinger et al., 2002), that are located within the Hudson River area above Hudson Falls and within the lower Mohawk River. The criteria to be used to identify off-site "candidate reference areas" will include:

- Gradient (from topographic maps);
- Fetch (from topographic maps);
- Adjacent land use (from orthophotos); and
- General geomorphic riverine features (width, sinuosity).

Candidate reference areas that have similar physical settings (defined by gradient, fetch, adjacent land use, and geomorphic features) as those areas within the project area will be further evaluated through field reconnaissance.

Step 2 of the approach will consist of a field reconnaissance of candidate reference areas. The reconnaissance will be conducted by boat, and will emphasize a semi-quantitative approach for each of the four habitats types (e.g., unconsolidated bottom, aquatic bed, shoreline, and wetlands). The purpose of this reconnaissance is not to exhaustively delineate or assess candidate reference areas; rather, it is to identify and document whether habitats similar to those in the project area are found upriver or on the lower Mohawk River.

For candidate off-site reference areas to be appropriate, the range of physical habitat conditions in these areas must fall within the range of habitat conditions within the proposed dredged areas. Therefore, the primary criterion for selecting candidate reference areas for further evaluation will be that the range of physical habitat conditions in these areas falls within the range determined for habitats at the project area. Given this overall criterion, a separate suite of physical habitat parameters will be evaluated for each habitat type to determine the appropriateness of each candidate area as a reference location:

1) *Unconsolidated Bottom*. Survey methods that will be used to identify potential reference locations for unconsolidated river bottom habitat include substrate probing (Natural Resource Conservation Service [NRCS], 1998) and a qualitative assessment of substrate type. Substrate probing will be conducted with lead lines, aluminum poles, or an appropriate device for a preliminary assessment of substrate type from the boat. Probing is used to survey large areas of substrate and detect changes in substrate type. A petite ponar grab will be used to sample sediment for field verification on the relative contribution of substrate types. The measurements for reconnaissance of the unconsolidated river bottom include:

   - water depth (meters [m]);
   - identification of obvious point sources; and
   - relative composition (%) of substrate (cobble, sand, silt, organics).

2) *Aquatic Vegetation Bed*. Survey methods that will be used to identify potential reference locations for aquatic beds will be conducted by boat. The approximate size of the bed will be determined and one or more small samples of submerged aquatic species collected using a weighted rake or petite ponar grab. The plant samples will be brought on board the boat for examination. The following measurements will be recorded:

   - water depth (m);
   - bed size (square meters [m^2])
   - percent cover
   - dominant species
   - identification of obvious point sources; and
   - shoot number (#) and length (centimeters [cm]) of representative plants.

3) *Shoreline*. Survey methods that will be used to identify potential reference locations for shorelines will follow rapid bioassessment guidance for using visual rapid survey of shoreline substrate and bank stability conditions (Barbour et al., 1999). The following measurements will be recorded:

   - identification of obvious point sources;
   - inorganic and organic substrate features (%);
   - bank stability (%) and vegetation cover (%); and

- riparian edge cover and extent (%).

4) *Fringing Wetland.* Visual survey methods will be used to identify potential "off-site" reference locations for fringing wetlands. The overall approach will be to document the location, approximate size, and relative contribution of emergent plant species in these wetlands. The following measurements will be recorded:

   - identification of obvious point sources;
   - relative size of wetland (m^2); and
   - plant type and relative dominance (%).

The general locations of candidate reference areas for each of the four habitat types will be recorded using GPS and the results of the field reconnaissance recorded in a field logbook. Photographs will be taken and archived for later use to aid in making a final determination on the use of these sites as project reference areas. The preliminary identification and field reconnaissance of candidate off-site reference areas will be conducted concurrently with habitat delineation activities in Year 2 of the SSAP (assumed to be 2003), and the results will be reported in the *Habitat Delineation Report*. If any candidate reference areas are identified that are suitable and appropriate for use as off-site reference areas (for the purpose described above) to augment information on reference conditions that may be attainable within the Upper Hudson River, they will be specified in the *Habitat Delineation Report*, and those areas will be delineated and assessed during the following year (assumed to be 2004), using the detailed habitat assessment methodologies described in Attachments A through D of this HDA Work Plan. The results of the detailed delineations and assessments of these off-site reference areas will be reported in the *Habitat Assessment Report* for Year 2.

2.2.1.2 Functions and Variables Selected for Measurement

As described in Table 2 (above), numerous ecological functions have been identified for each of the four habitat types covered by this HDA Work Plan. A detailed review and assessment process was used to consider each of the potential functions to ensure that the most useful and relevant were included in the habitat delineation and assessment program. First and foremost, the overall utility of the function, particularly in terms of habitat replacement and reconstruction efforts, was considered. For example, some functions must be established first, before others can be achieved (e.g., a shoreline must be stable enough to support large diameter trees, before large woody debris can accumulate). Second, the utility of the function for management decisions such as reallocating (or exchanging) functions among various habitat types was considered (e.g., when an SAV habitat is replaced with unconsolidated bottom habitat, if necessary). Third, redundant or correlative functions were removed from consideration.

As discussed above, in developing the habitat assessment procedures, we focused on direct measurements of the physical structure of the habitats to quantify the selected habitat functions. The specific structural parameters that will be measured for each function in each relevant habitat are listed in Table 2. The rationale for the selection of these structural parameters is discussed in the following sections and summarized, for each habitat, in Table 2 and Attachments A through D.

Critical to the viability of this approach is establishing relationships between structural elements and functions. To establish relationships between the structural parameters to be measured and functions, two activities will be performed. First, a thorough review of the scientific and regulatory literature will be completed to identify such relationships that have been established at other sites and to evaluate whether those relationships would be applicable to the Upper Hudson River. Second, existing data from the Upper Hudson River itself will be reviewed to establish relationships between structural and functional elements for this site, to the extent possible based on those existing data.

Additional data may be necessary to reduce uncertainty associated with such relationships. For example, a limited amount of benthic macroinvertebrate (BMI) and phytophilous macroinvertebrate (PMI) community data may be collected. These data have limited use for designing habitat reconstruction or replacement projects, which, as noted above, must focus on those corresponding structural parameters that can managed or manipulated if necessary to meet the project goals. However, such data may provide useful information for further assessing the relationships between structure and function. Thus, if necessary, BMI and PMI community data (e.g., biomass, abundance, and diversity of these organisms) may be collected from a subset of the unvegetated, aquatic bed, and wetland habitat sampling stations to reduce uncertainty in the relationships that were derived from the two methods described above or to establish relationships that cannot be established using those methods. The *Habitat Assessment Report* to be submitted to USEPA following each field season will identify any other types of data that need to be collected in the subsequent field season. In the event that GE or USEPA determines, in accordance with the RD AOC, that the collection of BMI and/or PMI community data, or other data, is necessary or appropriate for these purposes, GE will submit a separate protocol to USEPA for the collection of such data. If additional BMI or PMI community data are collected, they will be used as secondary biological criteria (as described in Section 1.2).

The structural measurements will provide habitat-specific data for use as design criteria and success criteria. The primary success criteria will be based on physical structural measurements of the replaced and/or reconstructed habitats, with the option of using direct functional data as secondary criteria if the primary criteria are not met, as discussed in Section 1.2 above. The structural measurements for each habitat type will be used to develop functional capacity indices (FCIs) for the relevant functions listed in Table 2 to allow for more comprehensive, management decisions regarding reallocation of functions among the replaced and reconstructed habitats, if required. These FCIs may be developed using pre-existing models (e.g., HSIs) or project-specific models, as discussed further in Section 2.4.

These following sections describe, for each habitat type, how habitat structure determines ecological function (e.g., the relationship of aquatic communities to the habitat), provide a brief rationale for the variables to be measured to quantify ecological function, and present the characterization tasks that will be used to document existing structural characteristics of Upper Hudson River habitats. Detailed methods for completing the habitat assessment tasks are provided in Attachments A through D of this HDA Work Plan.

2.2.2 River Bottom Habitats

Riverbed habitats can be separated into areas where vegetation is present or absent. The structure of non-vegetated river bottom habitats and vegetated river bottom (i.e., SAV) is discussed below, along with methods for assessing the function of these habitats within the Upper Hudson River.

2.2.2.1 Unconsolidated (Non-Vegetated) River Bottom

Substrate and surface-water flow may influence the abundance, composition, and distribution of BMI communities in and on unconsolidated bottoms. Typically, coarse sediments (e.g., cobble, rock, and coarse sand) are characteristic of substrates in systems of more rapid surface-water flow. Substratum represented by larger particles or stones is higher in structural complexity and supports a diverse macroinvertebrate community (Hynes, 1966). BMIs that prefer these habitats include mayflies (*Ephemeroptera*), stoneflies (*Plecoptera*), and caddisflies (*Trichoptera*) (Merritt and Cummins, 1984).

Fine sediments (e.g., fine sand and silt) are characteristic of depositional environments. In riverine habitats, fine sediments are often associated with dredged channels, pools, and river margins where reduced surface-water flow increases depositional processes. Fine sediments are typically colonized by macroinvertebrates that are tolerant of reduced-flow conditions. BMIs that prefer fine sediments include opportunistic species of aquatic earthworms (*Oligochaeta*) and midges (*Chironomidae*) (Merritt and Cummins, 1984). These groups often dominate (or co-dominate) invertebrate assemblages in sediments from depositional habitat systems.

Some fish species prefer rocky in-water habitat. For example, rock/cobble habitats are used by many species of fish as spawning substrate. Smallmouth bass (*Micropterus dolomieu*) (Sowa and Rabeni, 1995), and walleye (*Stizostedion vitreum)* (Niemuth et al. in Hartley and Kelso, 1991), spawn exclusively on rock or gravel beds in rivers and lakes. Additionally, greater species diversity is typically reported for fish collected over cobble/rubble shoals than over featureless sand substrate (Danehy et al., 1991; Snyder et al., 1996).

Therefore, based on this existing literature, the two important functions of unconsolidated river bottom habitat selected for assessment are: (1) the provision of habitat and food resources for macroinvertebrate communities; and (2) the provision of habitat and resources for fish populations. The former function is largely dependent on the availability of substrate for attachment or burrowing (substrate, cover and embeddeddness) and food resources (total organic carbon and percent fines). The latter function is largely dependent on food availability (determined by the support macroinvertebrate function), shelter (substrate and cover) and spawning habitat (embeddeddness and percent fines). Thus, the structural parameters to be measured to assess the above-listed functions will include substrate and cover, percent fines, total organic carbon, and embeddedness, as listed in Table 2. These measurements will be combined with detailed sediment characterization of the unconsolidated river bottom habitats in the Upper Hudson River (cobble-gravel, sand, mud, and organic substrates) using data collected during the SSAP and side-scan sonar program. Physical parameter measurements modified from USEPA Rapid Bioassessment Protocols (RBPs) (Barbour et al., 1999) will be used to characterize the bottom habitat. The specific methods, including RBP procedures, to be used in assessing unconsolidated bottom habitats are described in Attachment A to this HDA Work Plan.

2.2.2.2 Aquatic Vegetation Bed

Numerous studies have shown that SAV is excellent habitat for fish. SAV commonly contains large densities of macroinvertebrate prey (Scott, 1987; Hayse and Wissing, 1996; Gotceitas and Colgan, 1987; Bain and Boltz, 1992; Rozas and Odum, 1987; Cyr and Downing, 1998; Randall et al., 1996) that appear to be present due to the structural "complexity" of the plants (Gerrish and Bristow, 1979). In addition to food sources, fish find refuge and cover from predation in SAV beds (Mittelbach and Osenberg, 1993; Hayse and Wissing, 1996; Gotceitas and Colgan, 1987; Rozas and Odum, 1987; Randall et al., 1996). SAV beds may also serve as nursery habitat in rivers for juvenile game fish (Casselman and Lewis, 1996).

SAV beds increase the structural complexity of shallow water habitats, which has been suggested by several authors as the reason for increased species richness in these areas (Bain and Boltz, 1992; Randall et al., 1996). For example, a common species in the Upper Hudson River, largemouth bass (*Micropterus salmoides*), is most abundant in areas with vegetation (Jenkins et al., 1952; Miller 1975) and other forms of cover (e.g., logs, brush and debris). Other researchers have suggested that SAV beds support behavioral mechanisms related to foraging strategy or functional biology of a species. For example, northern pike (*Esox lucius*) are sedentary, lurking predators that prefer to forage in the cover afforded by shallow, vegetated areas (Cook and Bergersen, 1988; Casselman and Lewis, 1996). Similarly, carp (*Cyprinus carpio*), another species in the Upper Hudson River that forages in shallow water environments, may use SAV beds for sources of algae, seeds, and detritus (Kwak et al., 1992; Harris, 1987; Scott and Crossman, 1973).

SAV has been observed in the Upper Hudson River at varying densities during field studies conducted by GE in 1997 (Exponent, 1998) and 2002 (Exhibit B-1 to Attachment B). The two most common SAV species that were noted were water chestnut (*Trapa natans*) and water celery (*Vallisneria americana*). Water chestnut is a non-native invasive species and will be delineated and assessed to the extent that it occurs in the sampling locations, but will not be a component of any restoration or reconstruction effort. Habitat replacement efforts will focus on providing suitable conditions for recolonization of the area by appropriate and desirable species, such as water celery, in areas where water chestnut is removed as part of the remediation, to the extent feasible and consistent with the remediation design.

Water celery and other species observed during the field studies (e.g., *Elodea canadensis*, *Potamogeton nodosus*) provide structural habitat support for invertebrate and fish communities. Therefore, the assessments for the SAV habitats will focus primarily on the following functions: (1) primary productivity of the macrophytes; (2) habitat support for BMI and PMI communities; and (3) habitat support for fish populations. The first function is largely dependent on the amount of photosynthetic biomass (shoot biomass) over a given area (percent cover). The second of these functions is largely dependent on food availability for macroinvertebrates (shoot biomass), factors related to recruitment/settlement (shoot density, plant species composition, current velocity), and protection from predation (percent cover). The third function is largely dependent on food availability (the PMI/BMI function and shoot biomass), provision of nursery areas and protection from predation (shoot density and percent cover), and ease of access to adjacent habitats (percent cover, plant species composition).

In addition to these primary functions, concomitant functions that occur due to the physical presence of SAV will also be assessed. These will consist of substrate stabilization, water quality enhancement, and nutrient cycling. Substrate stabilization is largely dependent on the susceptibility of the sediment to resuspension (determined by percent fines in the sediment and current velocity) in relation to the dampening effect of the plants (shoot density and percent cover). Water quality enhancement is largely related to the ability of the plants (shoot density) to create a calm environment to allow particles to settle out of suspension (percent fines). Nutrient cycling is largely dependent on the amount of living (shoot biomass) and dead (percent fines) organic material available for recycling, and the availability of recycled nutrients for uptake by plants (sediment nutrient pools).

The specific measurements to be taken are related to the physical, chemical and biological factors that determine the ability of SAV to exist in a particular area (e.g., light, current, substrate; Koch, 2001) and measurements of the SAV itself (e.g., aboveground biomass, shoot density). Detailed information from representative SAV habitats will be collected to determine the range of conditions within which the SAV communities exist and the range of plant characteristics, including:

- **Plant Characteristics:** Information on species composition, shoot density, aboveground biomass, and percent cover will be collected and combined with historical data to define the range of plant community conditions that exist in River Sections 1 through 3.

- **Sediment Nutrient Availability:** Surface-sediment samples will be collected on each transect to determine exchangeable ammonia and phosphate (PO_{4-}). The nutrient data will be combined with the substrate characterization data obtained from samples collected under the SSAP and geotechnical data (specifically, bulk density, water content, USCS classification, grain size distribution, Atterberg limit, specific gravity, and total organic carbon) collected as part of the RD to define the range of existing nutrient conditions within which the SAV occurs.

- **Light Attenuation:** The light attenuation coefficient will be determined inside and outside of the SAV beds using appropriate handheld instrumentation (e.g., quantum sensors) to determine the range of light conditions within which SAV occurs. Water depth will also be recorded at the same locations where light levels are monitored.

- **Hydraulic Characteristics:** Current velocity (flow) will be determined inside and outside of the SAV beds using current velocity profiling equipment (e.g., handheld Marsh-McBirney profiling equipment) to define the range of conditions within which SAV occurs.

The specific protocols and sampling design for the activities to be conducted to assess the aquatic bed habitat are provided in Attachment B to this HDA Work Plan.

In addition to the field delineation and assessments of the aquatic bed habitat, information from the published literature and data that have been collected from other programs in the Upper Hudson River that are representative of aquatic beds will be used to aid in the development of a conceptual model for SAV habitats. These data will be obtained from the water quality monitoring component of the baseline monitoring program (e.g., on TSS and water column nutrients), data collected as part of the HDA activities (e.g., light attenuation, current velocity, sediment nutrients, water depth), and data (e.g., sediment type) from the SSAP. Combined, these data will be used to evaluate SAV habitats, including, as appropriate, development of a simplified conceptual SAV model for use in the habitat replacement and reconstruction program and the adaptive management program. Since such an SAV model will be used primarily as an assessment tool during replacement and reconstruction activities, it will be described as a specific element in the *Adaptive Management Plan.*

2.2.3 Shoreline Habitats

Shorelines along the Upper Hudson River are represented by a mix of developed and undeveloped bordering land uses. Typically, developed areas are where residential, commercial, or industrial properties have shorelines that are maintained or stabilized by rip-rap and bulkhead piling. Undeveloped shorelines have more natural features that may include riparian canopy and emergent wetlands. These shoreline types vary in the degree to which macroinvertebrates and fish are attracted to these habitats.

2.2.3.1 Maintained Shorelines

Maintained shoreline areas are, by definition, stabilized by the existence of the riprap, bulkhead piling, or concrete. As such, additional detailed habitat delineations and function assessments will not be completed for maintained shorelines under this HDA Work Plan. For those areas where remediation occurs adjacent to maintained shorelines, additional physical survey and engineering analysis may be required to address the stability of the structure(s) affected by the dredging operation. These situations will be addressed during the RD.

2.2.3.2 Natural Shorelines

Natural shorelines with an extensive riparian canopy serve many functions. An established canopy provides shade and cover, which can minimize daily and seasonal temperature fluctuations and keeps temperatures relatively cool (Schuytema, 1982; Sowa and Rabeni, 1995; Hunter, 1991). Deadfall (e.g., fallen and submerged trees) has been shown to provide cover for trout (Hunter, 1991), while also providing substrate for macroinvertebrates and “cover” for smaller fish. Yellow perch (*Perca flavescens*) are frequently associated with shoreline areas in lakes and reservoirs where there are moderate amounts of vegetation present (Herman et al., 1964; Ward and Robinson, 1974; Kitchell et al, 1977; Helfman, 1979). These areas provide both cover and spawning habitat. Suitable riverine habitat for yellow perch resembles the lacustrine habitat – i.e., pools and slack water areas with moderate amounts of vegetation (Coots, 1956; Kitchell et al., 1977)

Many of these functions provided by natural shorelines are based on the existence of a stable shoreline with sufficient vegetative cover and downfall to provide cover, shade, and habitat. Thus, the functions to be assessed in natural shorelines consist of shoreline stability, shade and cover, and the provision of wildlife habitat (Table 2). Shoreline stability is dependent on the existence of stable banks (low percentage of eroded area), protective vegetation (percentage of all vegetative layers present), and armoring against high flows (provided by downfall). Shade and cover are dependent primarily on the nature and type of vegetation present (downfall, riparian vegetation, bank vegetation). Wildlife habitat suitability is dependent on the nature and type of vegetation present (downfall, riparian vegetation, bank vegetation) and stability of the habitat (bank stability).

Given these functions and measurement variables, the assessments of the natural shorelines will include collecting the following data from representative locations on those natural shorelines adjacent to dredging areas and at reference locations to define the range of existing conditions:

- Bank slopes (using survey data);
- Presence of existing erosional areas (as determined visually and documented via survey for inclusion on the base maps);
- Presence of natural stabilizing material, such as large-diameter stones (determined visually and documented via oblique aerial photography); and
- Soil stratification (visual presence of exposed alluvial deposits, documented using video photography).

The specific protocols and sampling design for the activities to be conducted to assess natural shorelines are provided in Attachment C to this HDA Work Plan.

2.2.4 Fringing Wetland Habitats

Fringing wetlands provide spawning and nursery habitat for fish such as northern pike (Casselman and Lewis, 1996; Brazner and Magnuson, 1994). Brazner and Magnuson (1994) found higher fish species diversity and abundance in undeveloped wetland sites, as opposed to sandy beaches and developed sites. Wetlands and vegetative cover in general, provide greater structural complexity in the form of greater macrophyte diversity. Macrophytes support numerous prey species (Scott, 1987; Hayse and Wissing, 1996; Gotceitas and Colgan, 1987; Bain and Boltz, 1992; Rozas and Odum, 1987; Randall et al., 1996), making these vegetated areas more valuable as habitat to fish than non-vegetated sites.

The *Responsiveness Summary to the ROD* (USEPA, 2002b) explains that:

> “The goal of the wetland replacement actions generally will be to replace the wetland functions and values that existed before remediation. This will include the replacement of bird and mammal habitat. This effort will require the collection and documentation of extensive hydrology, soil and biological data on the pre-remediation conditions of the wetlands.”

The collection and documentation of assessment information for wetlands are described below.

Wetlands that will be directly impacted by remediation activities (and reference wetlands) will be delineated in accordance with the 1987 USACE *Wetland Delineation Manual*. Field investigations will be conducted and areas identified as wetlands (using the three-parameter approach) will be flagged and surveyed (USACE, 1987). Delineated wetland boundaries will be incorporated in the GIS database, and photo documentation and field data forms will be completed.

The functions to be assessed for wetlands and the measurements to be taken were selected based on the nature of the wetlands that will be assessed under this program. Specifically, the riverine wetlands in the Upper Hudson River that could potentially be impacted by remediation activities are relatively small fringing emergent wetlands, rather than the broader floodplain wetlands described in Ainslie et al. (1999) and Brinson et al. (1995). The functions to be assessed for these wetlands consist of:

1) Energy dissipation;
2) Surface-water exchange;
3) Primary production;
4) Nutrient cycling;
5) Removal and holding of elements/compounds;
6) Export of organic carbon;
7) Maintaining the character of the plant community; and
8) Provision of habitat for wildlife.

The specific structural parameters that will be measured for each of these eight relevant fringing emergent riverine wetland functions and the rationale for their selection are shown in Table 2 and Table D-1 in Attachment D. For example, the “surface-water exchange” function is dependent on the extent of the surface-water interface (determined by wetland area), the potential for infiltration to occur (presence of a fluctuating water table) and the residence time of the surface water (related to wetland slope).

Quantitative and qualitative data collection will be used to define the range of existing conditions in the field-delineated wetlands. The basic approach for this assessment will combine elements of the HGM methodology (modified from Ainslie et al., 1999; Brinson et al., 1995; and Findlay et al., 2002) with elements of other assessment techniques for wetlands (as described in Attachment D), and will include quantitative sampling of structural parameters to determine functions. The structural parameters to be measured include: wetland area, percent wetland edge altered, area of wetland buffer, slope, redoximorphic feature, presence of fluctuating water table, O Horizon (percent cover), A Horizon (percent cover), clay content, contiguous with other habitats (percent), plant species composition, stem density, stem thickness, stem length, and above-ground biomass.

Detailed protocols and sampling design for the assessment of the fringing wetlands are provided in Attachment D to this HDA Work Plan.

As noted above, this section and Attachment D focus on fringing wetlands (a single subclass in the riverine hydrogeomorphic class), since these types of wetlands are the ones most likely to be directly affected by dredging activities. In the event that wetlands from other riverine hydrogeomorphic subclasses (e.g., sheltered) are identified as being directly impacted by the dredging, those wetlands will be assessed consistent with the same procedures described above and in Attachment D for fringing wetlands.

2.3 Fish and Wildlife Surveys

In addition to the habitat assessment activities described in Section 2.2, which are focused on structural parameters associated with the relevant functions of each habitat, observational surveys will be conducted as a distinct task to document the occurrence of fish, birds, reptiles, amphibians and mammals as they are encountered in each of four habitat types. Specifically, during field operations associated with the habitat assessment activities, field personnel experienced in identifying wildlife species, will survey the habitat being assessed for the presence of wildlife using that habitat or for signs of such wildlife (e.g., calls, tracks, scat, slides, dens, burrows, daybeds, huts, etc.). Qualified personnel on the boats or on the shore will survey the surrounding habitat to document (by sight or by sign) the species using that habitat that can be observed from outside the water (e.g., diving ducks, wading birds), while in-water personnel will survey the submerged portion of the habitat for the presence or signs of species using that habitat (e.g., mussels, snails, turtles). In addition, fish surveys will be conducted by qualified field personnel during the baseline monitoring program electro-fishing events. During these events, the field team will record fish species observed in aquatic bed and unconsolidated river bottom habitats. For both the wildlife and the fish surveys, the personnel conducting the surveys will record the presence or signs of the species observed in the habitat type in question and a qualitative narrative synopsis of the observations (e.g., estimated size of the areal extent), using the form provided in Attachment E to this HDA Work Plan (Table E-1).

This information, along with other relevant existing information on fish and wildlife presence, will be used to document the association of species with habitats along the Upper Hudson River during the pre-remedy phase to obtain information that may be useful in designing the replacement or reconstructed habitats and to confirm the assessment of habitat suitability. As discussed previously in Section 1.2, these direct functional data will not be used in the first instance as success criteria for the habitat replacement and reconstruction program. Thus, the absence of any previously observed species from a given habitat during any phase of the project will not be used to infer that habitat function is in any way impaired. However, if the success criteria based on structural parameters are not met in a given dredged location, the information on fish and wildlife presence will be used as secondary success criteria, such that if the fish and wildlife in that dredged area are comparable to those observed to be using that habitat prior to dredging or in the reference areas for that habitat, the replacement/reconstruction of that area will be considered successful.

2.4 Development of FCIs

Following completion of the field components of the habitat assessment activities and compilation of the resulting data on structural parameters, the specific measurements taken for each habitat type will be used to develop FCIs for each relevant function for that habitat (as listed in Table 2). FCIs are values calculated from the field and laboratory measurements that provide a site-specific basis for describing the functions being performed by that habitat at a specific location and for comparing functional capacity among locations. These types of models have been variously described as multiple-criterion models, composite indices, or multi-metric models and have been used extensively in environmental impact assessment (e.g., Smith and Wakeley, 2001). The conceptual foundations for the application of FCIs are discussed generally in Ainslie et al. (1999) and Smith and Wakeley (2001), and specifically for the Hudson River in Findlay et al. (2002). While the focus of those studies was on riverine wetlands, the overall approach to developing and using FCIs is generally applicable to and will be used for characterizing the habitat types to be assessed for this project.

For the functions relating to the provision of habitat for particular biotic species, pre-existing HSIs may be used as the FCIs. HSIs exist for numerous species and may be used for representative indicator species identified for a given habitat type during the fish and wildlife surveys described in Section 2.3 or by other available information. Under this approach, the data necessary for completion of the HSI for the given species will be combined to provide an overall HSI value for that habitat type and species at any given area. Key species for which HSIs will be calculated will be identified in the *Habitat Delineation Report*.

For functions for which appropriate pre-existing models do not exist, project-specific FCI models will be developed to quantify those functions. The specific methods used to develop FCIs for the various functions of each habitat type will be described and preliminary FCI models will be provided in the *Habitat Delineation Report*. Finalized FCI models, together with underlying data and the FCI results, will be provided in the *Habitat Assessment Reports*.

3. Threatened and Endangered Species Assessment

The USEPA has initiated preliminary consultation with the United States Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) regarding the need for conducting a BA for threatened and endangered species related to remediation of PCB-containing sediments in the Upper Hudson River. Documentation regarding this prior consultation is discussed in the ROD (USEPA, 2002b) and presented in the Administrative Record. This section describes the approach for assessing and reporting potential adverse impacts of implementing the ROD on threatened and endangered species and species of special concern or on the critical habitat of such species.

3.1 General

The ROD (page 31) identifies a number of species that are considered threatened, endangered, rare, or of special concern by Federal and New York State agencies. There are two species that are of particular concern in implementing the ROD to address the PCB-containing sediments in the Upper Hudson River: the bald eagle (*Haliaeetus leucocephalus*) and the shortnose sturgeon (*Acipenser brevirostrum*). The bald eagle is federally and state-listed as threatened and the shortnose sturgeon is federally listed as endangered (USEPA, 2002b; NMFS, 1998). Under the Endangered Species Act (ESA), both species will require BAs that will be used to determine the need for formal consultation and will aid in developing biological opinions (BOs), if formal consultation is required, from the USFWS for the bald eagle and from NMFS for the shortnose sturgeon regarding the potential for incidental "take" of these species during implementation of the dredging-related activities called for in the ROD. "Take" is defined under Section 3 of the ESA as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct (see also 50 CFR § 17.3. Incidental take is understood to occur should the activities associated with implementing the ROD adversely affect these species' habitat and/or mating behavior (USEPA, 2002b).

A BA evaluates the potential effects of a proposed action on listed species (and corresponding habitat) so that the likelihood of adverse effects on any such species or habitat by the proposed action can be evaluated. A BA is also used to determine whether additional consultation is required. In the ROD, the USEPA has identified the expectations of a BA. Any completed BAs will include an effects determination, which will state the conclusions regarding potential impacts to the local population or to an individual of the species that can be supported from the information presented in the BAs. The BAs will be submitted to the USFWS or NMFS for review and concurrence or non-concurrence. The BAs will be completed before remedial construction, and the remedial design will address appropriate measures to protect these species that result from the consultation process.

A BA will be prepared with separate sections for the bald eagle and the shortnose sturgeon. The ROD identifies two other species, the Karner blue butterfly (*Lycaiedes melissa samuelis*) and the Indiana bat (*Myotis sodalis*), as potentially found in the area, but these species are expected to rely on habitats well outside of the river banks. Therefore, potential impacts to the Karner blue butterfly and the Indiana bat are expected to be limited to activities associated with the land-based sediment processing/transfer facilities and associated terrestrial access routes to the river. An evaluation of potential impacts to federal threatened or endangered species associated with the sediment processing/transfer facilities will be carried out by USEPA, as necessary, in accordance with the Facility Siting Concept Document (USEPA 2002a).

For other species, the NYSDEC Natural Heritage Program and appropriate federal agencies will be contacted, prior to commencing field activities, to obtain a list of rare, threatened and endangered species of biota or sensitive habitats that could potentially occur within the 40-mile project area. If such species or habitats are observed during field activities, their occurrence and specific location(s) will be documented in the *Habitat Delineation Report* and the *Habitat Assessment Reports*. These data will also be incorporated as appropriate into future design documents.

3.2 Biological Assessment

No field work is planned for the BA for the bald eagle and the shortnose sturgeon. Rather, existing information from “in-place” monitoring programs will be used, which will avoid interaction with these species through contact or handling. This approach will involve: (1) conducting interviews with recognized experts on the bald eagle and the shortnose sturgeon, including those with the USFWS, NYSDEC, NOAA, NMFS, universities, and others who may have data not yet found in the peer-reviewed scientific literature; and (2) reviewing up-to-date literature and scientific data to determine the distributions of these species, habitat needs and use, and other biological requirements.

The BA will be prepared through a compilation of the available information on the species. During development of the BA, the necessity of conducting “non-intrusive” field work can be determined. If such field work is deemed necessary, appropriate biological sampling plans will be prepared and submitted to USEPA for review and approval.

3.2.1 Bald Eagle

This task will include coordinating with the USEPA, USFWS, and NYSDEC to establish the BA area for the bald eagle. There are several efforts underway by biologists at the NYSDEC to track the movement of bald eagles throughout the year as they nest or migrate to wintering sites. Some of the pairs are fitted with tracking devices, while others are observed by wildlife biologists, to better understand the bald eagles' life history requirements and interaction with humans. This information will be collected and reviewed for purposes of preparing the BA.

New York State wildlife biologists participating in programs that are already monitoring the habitat use and behaviors of these birds will be contacted to gain information on the scope of these field surveys. These biologists will also serve as experts for providing views on the interaction of the species with project activities.

The information collected from "in-place" monitoring programs will be compiled and evaluated to assess potential impacts on bald eagles by the dredging-related activities, and conservation recommendations will be developed as needed.

3.2.2 Shortnose Sturgeon

The potential for direct, indirect, and cumulative adverse impacts from the dredging-related remedial activities to the shortnose sturgeon will be assessed by compiling existing information about the distribution and life history of this species. This information will be obtained through coordination with various federal and state agencies (e.g., NMFS) and researchers, on their records of the distribution of this species. Researchers involved in monitoring the migratory and spawning behavior, and habitat use of shortnose sturgeon in the Hudson River will be contacted to gather information on the potential effect of project activities on this species.

Existing information on the distribution and life history attributes of the shortnose sturgeon will be compiled, and potential impact to shortnose sturgeon by the dredging-related remedial activities will be evaluated. In addition, if necessary, appropriate conservation recommendations will be developed.

3.3 BA Reporting and BOs

Based on the information described above, a BA will be prepared and submitted to USEPA for the bald eagle and shortnose sturgeon. The BA will contain the following information:

- The results of the consultation with the relevant agencies, interviews with experts, literature reviews, and any other available information on the distribution, habitat use, and biological requirements of the species in question within the potentially affected area;
- An analysis of the effects of the dredging project on individuals and populations of each species and their habitat, including indirect and cumulative effects of the action;
- An analysis of alternative actions that may provide conservation measures, if needed; and
- A review and summary of other information determined to be relevant (e.g., other BAs).

A single BA, with a separate section for each species, will be submitted to USEPA after completing the relevant information collection activities and after sufficient information regarding the remedial action is available to allow a BA for the overall project to be completed. In addition to the work outlined in this Section 3 of the HDA Work Plan, completion of the BA depends on USEPA's issuance to the public of (a) the draft engineering performance standards for the remedial action, and (b) the list of final candidate sites for the sediment processing/transfer facility(ies) for Phase 1 and Phase 2 of the remedial action.

GE will prepare the BA and submit it to USEPA. USEPA will review the BA and, after consultation with GE, make any changes or additions that it determines are necessary to address the performance standards and/or the sediment processing/transfer facility site(s). USEPA will then provide this BA, with any changes or additions by USEPA, to the USFWS and NMFS for their review and issuance of BOs (if needed) or written concurrence with a determination in the BA of not likely to adversely affect. USEPA will seek to obtain BOs or written concurrence from the USFWS and NMFS before completion of Intermediate Design for Phase 1. Such BOs or written concurrence from the USFWS and NMFS and a determination by USEPA, if necessary, as to the measures necessary to be incorporated into the design to address any "reasonable and prudent measures," "terms and conditions," or "conservation measures" identified by the USFWS or NMFS are a prerequisite for the completion of Final Design for Phase 1. It is expected that review by USFWS and NMFS and issuance of their respective BOs (if needed) or written concurrence with a determination of not likely to adversely affect will occur within a timeframe such that completion of the RD is not delayed.

4. Schedule

The SSAP activities described in this HDA Work Plan (i.e., the side-scan sonar surveys) are already underway as part of that program (see SSAP-FSP [QEA, 2002]). The remaining activities described in this HDA Work Plan will be initiated upon approval of this HDA Work Plan by the USEPA and execution of the RD AOC. The schedule for those remaining activities is described in this section.

Habitat delineation activities will be conducted for all three river sections in the field season immediately following execution of the RD AOC (i.e., Year 2 of the SSAP, anticipated to be 2003). Habitat assessments will also be conducted in that same field season for the candidate Phase 1 areas (as identified in the RD Work Plan). The results of the habitat delineation activities for all River Sections (which will consist of the habitat maps) will be provided in a *Habitat Delineation Report*, and the results of the detailed habitat assessment activities for the candidate Phase 1 areas will be provided in a *Habitat Assessment Report* for the candidate Phase 1 areas. These reports will be submitted concurrently, in accordance with the schedule set forth in the RD Work Plan (BBL, 2003) – i.e., within eight months from the effective date of the RD AOC. Any additional habitat assessment data needs will be noted in the *Habitat Assessment Report* for the candidate Phase 1 areas.

Habitat assessments for the dredge areas covered by the *Year 2 Dredge Area Delineation Report* will be conducted in the following field season (anticipated to be 2004) after USEPA approval of that *Dredge Area Delineation Report*. The specific areas to be sampled/evaluated as part of those functional assessments will be presented in the *Supplemental Engineering Data Collection Work Plan* for Year 3; and the results will be presented in a *Habitat Assessment Report* for Year 2, which will be submitted in accordance with the schedule set forth in the RD Work Plan (BBL, 2003) – i.e., on the same date to be proposed by GE and approved by USEPA for submission of the *Supplemental Engineering Data Collection Report* for Year 3. In addition, a subset of the dredge and reference areas delineated and/or assessed during each of these field seasons will be spot-checked and reassessed as necessary in subsequent years to assess fluctuations in size or location of habitat types, particularly SAV beds. This subsequent spot-checking for variability will include areas delineated and/or assessed during both years of the HDA program.

As indicated in Section 3.3, the BA for the bald eagle and the shortnose sturgeon will be submitted as soon as sufficient information has been compiled for the BA to be considered complete. Specifically, the BA will be submitted to USEPA within 90 days after the later of: (a) USEPA's issuance to the public of the draft engineering performance standards for the remedial action; or (b) USEPA's issuance to the public of the list of final candidate sites for the sediment processing/transfer facility(ies) for Phase 1 and Phase 2 of the remedial action. USEPA will then provide this BA, with any changes or additions by USEPA, to the USFWS and NMFS for their review and issuance of BOs (if needed) or written concurrence with a determination in the BA of not likely to adversely affect. USEPA will seek to obtain BOs or written concurrence from the USFWS and NMFS before completion of the Intermediate Design for Phase 1. Such BOs or written concurrence from the USFWS and NMFS and a determination by USEPA, if necessary, as to the measures necessary to be incorporated into the design to address any “reasonable and prudent measures,” “terms and conditions,” or “conservation measures” identified by the USFWS or NMFS are prerequisites for the completion of Final Design for Phase 1, as described in the RD Work Plan (BBL, 2003).

Findings from the habitat delineation and assessment program will support Final Design activities.

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Attachment A. Standard Operating Procedure for Unconsolidated (Non-Vegetated) River Bottom Assessment

I. Objective

The objective of this Standard Operating Procedure (SOP) is to set forth methods to measure the range of existing conditions of unconsolidated (non-vegetated) river bottom habitats within River Sections 1, 2, and 3 of the Upper Hudson River. The assessment activities that will be performed in the field are described generally in Section 2.2.2.1 of the *Habitat Delineation and Assessment Work Plan* (HDA Work Plan; Blasland, Bouck & Lee, Inc. [BBL], 2003) for the Upper Hudson River. This SOP provides a methodology for collecting information to document the range of conditions in the unconsolidated river bottom habitat as it currently exists.

Measurements described in this SOP are based on physical characteristics of habitat structure. Habitat structure is defined as the physical components and the organization or pattern of a habitat, community or ecosystem. Habitat structure and ecological functions are intrinsically linked, and in general, when there is suitable habitat structure, aquatic communities and associated ecosystem functions are present. This approach is consistent with the Record of Decision (ROD) for the Upper Hudson River (United States Environmental Protection Agency [USEPA], 2002) and previous studies that have shown that successful fluvial replacement and reconstruction projects depend mainly on the presence of suitable physical habitat (e.g., Gore, 1985).

The functions to be assessed for the unconsolidated river bottom habitats and the specific measurements to be taken in the field to quantify those functions, along with a brief rationale for each, are shown in Table A-1 (below). The measurements will be used to develop functional capacity indices (FCIs) for unconsolidated bottom functions, so as to allow for management decisions regarding reallocation of functions among the replaced and reconstructed habitats, if necessary. FCIs are values calculated from the field habitat measurements that provide a synthesis of information for evaluating habitat functions – in this case, the functions listed in Table A-1. FCIs provide a site-specific basis for describing the functional capacity of a habitat at a specific location, and for comparing functional capacity among locations. In developing these FCIs, pre-existing models such as Habitat Suitability Indices (HSIs) may be used (for specific representative indicator species) or project-specific FCI models may be developed. The conceptual foundations for the application of project-specific FCIs are discussed generally in Ainslie et al. (1999) and Smith and Wakeley (2001), and specifically for the Hudson River in Findlay et al. (2002). While the focus of these studies was on riverine wetlands, the overall approach to developing and using FCIs is applicable to and will be used for characterizing unconsolidated bottom habitats.

Table A-1. Unconsolidated River Bottom

Function	Measured Variable	Rationale
Potential to Support Macroinvertebrates	Total organic carbon Substrate and cover Embeddedness Percent fines	Food resources for BMI Protection from predation; attachment Availability of cobble, gravel for attachment Burrowing substrate; related to TOC
Potential to Support Fish Populations	Substrate and cover Embeddeness Percent fines	Protection from predation; spawning substrate Availability of cobble, gravel for spawning substrate Related to embeddedness

FCIs will be developed for each function listed in Table A-1 and each station sampled (as described in Section III below). These FCIs, together with the underlying data, associated maps (as necessary), and the specific protocols used to develop the FCIs, will be presented to USEPA in the *Habitat Assessment Reports* referenced in the HDA Work Plan.

II. Necessary Materials and Equipment

- Small boat with standard water safety gear (e.g., personal flotation device [PFD]; first aid kit)
- Protective gear for working in water (e.g., hip waders, wetsuit, drysuit)
- Foul weather gear
- Rapid Bioassessment Protocols (RBP) guidance document
- Differential Global Positioning System (DGPS) unit
- Dive equipment (diving flag, SCUBA and/or snorkel)
- Camera
- Binoculars
- Field guide(s)
- Field log book

III. Sampling Design

As described in the HDA Work Plan, unconsolidated bottom habitats will be delineated and mapped based on the side-scan sonar output and substrate characterization data from the Sediment Sampling and Analysis Program (SSAP). That program will provide sonar coverage of the entire river bottom, along with approximately 6,000 surface sediment samples with total organic carbon measurements and sediment classification and 450 samples with quantitative analyses for grain size distribution. As part of habitat delineation activities, the information from side-scan sonar and sediment sampling programs will be integrated into a series of overlay habitat delineation maps. These maps will be used to identify a suite of sampling strata for the detailed habitat assessment activities. These strata will be based on one or more key parameters relevant to unconsolidated river bottom habitats, such as sediment type, three-dimensional structure, flow, overlying water depth, presence of organic macroparticles, and others as appropriate.

Unconsolidated bottom comprises a large proportion of in-river habitat in the Upper Hudson River. Based on existing information, it is estimated that approximately 2,700 acres (approximately 1100 hectares) of unconsolidated bottom habitat is present in River Sections 1, 2 and 3 (approximately 3900 acres of total river bottom in project area minus approximately 1,200 acres of vegetated river bottom habitat). The detailed habitat assessment activities will be conducted in a representative portion of that total habitat area, with the goal of conducting such activities in approximately 5% of the total area of unconsolidated bottom. Based on the assumption that a sampling station would cover, on average, approximately one acre, a total of 135 representative sampling stations will be selected for the detailed functional assessment. These stations will be selected, using the information from the habitat delineation maps, side-scan sonar output, and substrate characterization, together with available information on areas to be dredged, so as to meet the following criteria:

1. Adequately characterize all the habitat strata identified from the habitat delineation information, as described above;

2. Include a roughly equivalent number of target stations (in dredge areas) and reference stations (in non-dredge areas); and

3. Be allocated among River Sections in rough proportion to the relative areas of unconsolidated river bottom habitats to be dredged in each River Section.

At each sampling station, nine samples will be collected, for a total of 1,215 samples. The use of nine samples per station provides flexibility in the design so that multiple strata within each station can be sampled with replication. The specific sample points will be selected to best characterize the strata within the station. (Note that samples will be located within stations as appropriate to cover the strata present and based on the amount of dredging to be completed. Thus, an area of uniform bottom or where limited dredging is planned will receive fewer sample points than an area of heterogeneous bottom or where more extensive dredging is planned.)

IV. Methods

The protocols described in this SOP for assessing unconsolidated river bottom habitat are adapted from the USEPA Rapid Bioassessment Protocols (Barbour et al., 1999). Sampling will be conducted by trained, experienced personnel (per Barbour et al., 1999) using SCUBA, snorkeling gear, or wading. Sample locations will not be disturbed by sampling personnel prior to making habitat parameter estimates.

Habitat parameters will be determined in areas where unconsolidated bottom is present. Areas to be sampled within the unconsolidated habitat will be determined as described in Section III. Following the collection and review of side-scan sonar output and substrate characterization data from the SSAP, sampling will be conducted between June 1 and September 30 in accordance with the following steps:

1. Establish the nine sampling points at each station (as described in Section III). The sampling points will be located such that replicate measurements are taken randomly from within each stratum at the station. Record locations with DGPS. Also record weather conditions on and prior to the day of the survey, as well as watershed and in-stream features, in the field log book.
2. As described by Barbour et al. (1999), estimate and record percent composition of inorganic features of the substrate observed in the sampling area (approximately 2.0 m^2), using Table A-2, by visual and/or tactile evaluation.

Table A-2. Inorganic Substrate Components		
Substrate Type	Diameter (millimeters [mm])	Percent Composition (0-100%)
Bedrock		
Boulder	> 256 mm (10 inches)	
Cobble	64 – 256 mm (2.5 – 10 inches)	
Gravel	2 – 64 mm (0.1 – 2.5 inches)	
Sand	0.06 – 2 mm (gritty)	
Silt	0.004 – 0.06 mm	
Clay	<0.004 mm (slick)	

(Adapted from Barbour et al., 1999)

3. As described by Barbour et al. (1999), estimate and record percent composition of organic features of the substrate, using Table A-3, in the same area and by the same techniques as described in Step 2.

Table A-3. Organic Substrate Components		
Substrate Type	Characteristic	Percent Composition (0-100%)
Detritus	Sticks, wood, course plant material (CPOM)	
Muck-Mud	Black, very fine organic (FPOM)	
Marl	Grey, shell fragments	

(Adapted from Barbour et al., 1999)

4. As described by Barbour et al. (1999), estimate and record the presence and character of structural substrate/habitat cover, using Table A-4, in the same area and by the same techniques as described in Step 2.

Table A-4. Epifaunal Substrate / Available Cover		
Category	Stable Habitat (For Low Gradient Conditions)	Stable Habitat (For High Gradient Conditions)
Optimal – mix of snags, submerged logs, cobble, or other stable habitat	> 50%	> 70%
Suboptimal – mix of stable habitat well-suited for colonization and new fall	30 – 50%	40 – 70%
Marginal – habitat availability less than desirable; substrate frequently disturbed or removed	10 – 30%	20 – 40%
Poor – lack of habitat obvious; substrate unstable or lacking	< 10%	< 20%

(Adapted from Barbour et al., 1999)

5. As described by Barbour et al. (1999), estimate and record the level of embeddedness of large-diameter material, using Table A-5, in the same area by the same techniques as described in Step 2. Do not complete this step if the substrate is greater than 75% sand, silt, or clay. Complete this step only for high gradient areas.

Table A-5. Embeddedness

Category	Surrounded by Fine Sediment
Optimal – gravel, cobble and boulder particles largely uncovered; layer of cobble provides diversity of niche space	0 – 25%
Suboptimal – gravel, cobble and boulder particles partially covered	25 - 50%
Marginal – gravel, cobble and boulder particles more than 50% covered	50 – 75%
Poor – gravel, cobble and boulder particles mostly covered and difficult to discern	> 75%

(Adapted from Barbour et al., 1999)

6. As described by Barbour et al. (1999), estimate and record the level of optimal pool substrate characteristics using Table A-6 in the same area by the same techniques as described in Step 2. Complete this step only for low gradient areas.

Table A-6. Pool Substrate Characterization

Category	Stable Habitat[1]
Optimal – mix of substrate materials, with gravel and firm sand prevalent; root mats and SAV common	> 80%
Suboptimal – mix of soft sand, mud or clay; mud may be dominant; some root mats and SAV present	55 – 75%
Marginal – all mud or clay or sand bottom; little or no root mat; no SAV	30 – 50%
Poor – hard-pan clay or bedrock; no root mat or SAV	< 25%

(Adapted from Barbour et al., 1999)

[1] Values of percent derived from scores associated with each category (Barbour et al, 1999)

7. As described by Barbour et al. (1999), estimate and record the channel flow status using Table A-7 in the same area by the same techniques as described in Step 2.

Table A-7. Channel Flow Status

Category	Percent Channel Filled with Water
Optimal – water reaches base of both lower banks and minimal amount of channel substrate is exposed.	100%
Suboptimal – water fills > 75% of available channel; or < 25% of channel substrate is exposed.	> 75%
Marginal – water fills between 25-75% of channel and/or riffle substrates are mostly exposed.	25 – 75%
Poor – very little water in channel and mostly standing pools.	< 25%

(Adapted from Barbour et al., 1999)

8. Repeat the observations at one sampling point per station using different crew member and compare observations on percent composition. Stations where repeated observations deviate from original estimates by 20% or more will be reassessed.

9. When on station, qualified topside personnel shall survey the surrounding unconsolidated bottom to document the occurrence or signs of wildlife species that can be observed by these personnel (e.g., diving ducks). In addition, in-water personnel shall survey the area of unconsolidated bottom being sampled for the occurrence or signs of in-water wildlife species, such as mussels, snails, or vertebrates (e.g., turtles). Record observations, including a qualitative narrative synopsis, on Table E-1 provided in Attachment E to the HDA Work Plan.

10. Move to the next sampling point and repeat Steps 2 through 9.

As discussed in Section I, the specific habitat parameter results described above will be used to develop FCIs (which may include HSIs) for each function listed in Table A-1 (above) and each station sampled. The approach to be used in developing the FCIs will follow the same general approach used by Ainslie et al. (1999) and Findlay et al. (2002) and/or may use pre-existing HSI models. If HSIs are used, HSI information for selected indicator species will be obtained from http://www.nwrc.usgs.gov/wdb/pub/hsi/hsiindex.htm. Preliminary FCI models and the lists of species for which HSIs (if used) will be calculated will be provided in the *Habitat Delineation Report*. The specific methods used will be described, together with the underlying data and the FCI results, in the *Habitat Assessment Reports* referenced in the HDA Work Plan.

It should be re-emphasized that the steps described above are those modified from Barbour et al., (1999) for visually surveying stream and wadeable river habitats through a rapid bioassessment approach. Other components of the protocols by Barbour et al. (1999) (e.g. record of velocity/depth, pool variability, and sediment deposition) that are not described in this SOP would not be achievable for a visual survey of unconsolidated river bottoms in the mostly unwadeable habitats of the Upper Hudson River. Therefore, for these components, the data collected as part of the SSAP will be used to assign scores, as applicable.

V. References

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Attachment B. Standard Operating Procedure for Aquatic Bed Assessment

I. Objective

The objective of this Standard Operating Procedure (SOP) is to set forth methods to measure the range of existing conditions, including cover, shoot density, and above-ground biomass, within submerged aquatic vegetation (SAV) habitats in River Sections 1, 2, and 3 of the Upper Hudson River. The assessment activities that will be performed are described generally in Section 2.2.2.2 of the *Habitat Delineation and Assessment Work Plan* (HDA Work Plan; Blasland, Bouck & Lee, Inc. [BBL], 2003). This SOP provides further details on the procedures for collecting information to document the range of conditions in the aquatic bed habitats.

Measurements described in this SOP are based primarily on characteristics of habitat structure. Habitat structure is defined as the physical components and the organization or pattern of a habitat, community or ecosystem. Habitat structure and ecological functions are intrinsically linked, and in general, when suitable habitat structure exists, aquatic communities and associated ecosystem functions are present. The approach described in this SOP is consistent with the Record of Decision (ROD) for the Upper Hudson River (United States Environmental Protection Agency [USEPA], 2002) and previous studies that have shown that successful fluvial replacement and reconstruction projects depend mainly on the presence of suitable physical habitat (e.g., Gore, 1985).

The functions to be assessed for the aquatic bed habitats, the specific measurements to be taken in the field and laboratory to quantify those functions, and a brief rationale for their measurement are shown in Table B-1. The measurements will be used to develop functional capacity indices (FCIs) for the aquatic bed functions, so as to allow for management decisions regarding reallocation of functions among the replaced and reconstructed habitats, if necessary. FCIs are values calculated from the field habitat and laboratory measurements that provide a synthesis of information for evaluating habitat functions – in this case, the functions listed in Table B-1 (below). FCIs provide a site-specific basis for describing the functional capacity of a habitat at a specific location, and for comparing functional capacity among locations. For the functions related to providing habitat for fish, pre-existing Habitat Suitability Indices (HSIs) may be used for specific representative indicator species. Otherwise, project-specific FCI models will be developed. The conceptual foundations for the application of project-specific FCIs are discussed generally in Ainslie et al. (1999) and Smith and Wakeley (2001), and specifically for the Hudson River in Findlay et al. (2002). While the focus of these studies was on riverine wetlands, the overall approach to developing and using FCIs is generally applicable to and will be used for characterizing aquatic bed habitats.

Table B-1. Aquatic Bed

Function	Measured Variable	Rationale
Macrophyte Primary Productivity	Shoot biomass Percent cover	Represents productivity Areal extent of productivity for SAV bed
Support PMI/BMI Populations	Shoot biomass Shoot density Percent cover Plant species composition Light availability Water depth Current velocity	Represents available food resources for BMI/PMI Substrate for PMI settlement; dampens wave/current energy Protection from predation Plant architecture related to number of PMI Growth productivity of SAV and epiphytes Correlated to light availability Settlement of PMI; scouring of BMI habitat
Provide Habitat for Fish Populations	Shoot biomass Shoot density Percent cover Plant species composition	Represents available food resources for BMI/PMI Related to ease of movement within SAV bed Protection from predation; access to open water Meadow versus canopy species offer differing levels of protection / access
Stabilization of Substrate	Shoot density Percent cover Percent fines Current velocity	Dampens wave/current energy Areal extent of dampening effect Related to potential for resuspension of sediment Higher current scours or resuspends more sediment
Water Quality Enhancement	Shoot density Percent fines	Shoots dampen wave/current energy allow particles to settle out of suspension Related to potential for resuspension of sediment
Nutrient Cycling	Shoot biomass Percent fines Sediment nutrient availability	Standing crop of organic material Related to anaerobic conditions (allows denitrification); related to organic material in sediment Indicates availability of nutrients cycled from organic matter

FCIs will be developed for each function listed in Table B-1 and each station sampled (as described in Section III below). These FCIs, together with the underlying data, associated maps (as necessary), and the specific protocols used to develop the FCIs, will be presented to USEPA in the *Habitat Assessment Reports* referenced in the HDA Work Plan.

II. Necessary Materials and Equipment

- Small boat with standard water safety gear (e.g., personal flotation device; first aid kit)
- Differential Global Positioning System (DGPS) unit
- Protective gear for working in water (e.g., hip waders, wetsuit, drysuit)
- Dive equipment (e.g., diving flag, SCUBA and/or snorkel gear)
- Field log book
- Sampling quadrat (1 meter [m] x 1 m, polyvinyl chloride [PVC]) with permanent marks every 25 centimeters (cm) on each side
- Sampling subquadrat (25 cm x 25 cm, PVC)

- Tubes for collecting sediment cores (PVC or Lexan)
- Light meter (photoactive radiation sensor)
- Sounding line, calibrated in centimeters
- Water velocity meter
- Random number table
- Sealable storage bags, pre-labeled
- Cooler(s) with ice
- Range finder (optical)
- Camera
- Binoculars
- Field guide(s)
- Laboratory support equipment (e.g., jars, labels, etc.)

III. Sampling Design

As described in the HDA Work Plan, aquatic bed habitats will be delineated and mapped based on aerial photographs and in-field ground-truthing of that remotely sensed information, as well as the side-scan sonar output and substrate characterization data from the Sediment Sampling and Analysis Program (SSAP). That program will provide sonar coverage of the entire river bottom, along with approximately 6,000 surface sediment samples with total organic carbon measurements and sediment classification and 450 samples with quantitative analyses for grain size distribution. As part of habitat delineation activities, the information from the aerial photographs, ground-truthing, and SSAP will be integrated into a series of overlay habitat delineation maps. These maps will be used to identify a suite of sampling strata for the detailed habitat assessment activities. These strata will based on one or more key parameters relevant to aquatic bed habitats, such as bed size, species composition, plant cover, sediment type, flow, overlying water depth, and others as appropriate.

To assist in developing a sampling design for characterizing aquatic bed habitats, a limited preliminary field study was conducted in aquatic beds in the Upper Hudson River in August 2002. Based on the field team's experience in aquatic bed sampling and reconnaissance of beds in the river, seven stations were sampled in the 2002 study: six stations within River Section 1 and one station in River Section 2. At each station, three transects were placed perpendicular to shore, and three quadrats were randomly placed along a transect for a total of nine samples per station. The quadrats were used to define the area within which samples were collected (shoot density and biomass) and from which percent cover was recorded. A map showing the locations of those stations and a table summarizing the results are provided in Figure B-1 and Exhibit B-1 to this SOP.

After considering observations made during the August 2002 field investigation and the results of the investigation and data analysis, it was determined by professional judgment that a distribution of (on average) approximately two sampling stations (of nine samples each) per river mile of potentially impacted aquatic bed habitat, with a corresponding distribution of stations in unimpacted (reference) areas, would be appropriate for characterizing aquatic bed habitats. Based on our current knowledge about the distribution of aquatic bed habitat in the Upper Hudson River, aquatic bed habitat over an approximate 13-mile area may potentially be impacted by the proposed remedial activities. Data collected during the assessment of candidate Phase 1 areas will be used to further assess the variability between sampling locations and to evaluate whether any modification to the sampling design is warranted. The results of such further assessment will be provided to USEPA, along with any proposal to modify the sampling program arising out of the further assessment.

Based on the foregoing evaluation, 52 stations will be selected for the detailed functional assessment of aquatic bed habitat (26 in dredge areas and 26 in reference or non-dredge areas). These stations will be selected, using the information from the habitat delineation maps, side-scan sonar output and substrate characterization, together with available information on areas to be dredged, so as to best meet the following criteria:

1. Adequately characterize all aquatic bed habitat strata identified from the habitat delineation information, as described above;
2. Include an equal number of target stations (in dredge areas) and reference stations (in non-dredge areas), as also described above; and
3. Be allocated among River Sections in a rough proportion to the relative areas of aquatic bed habitat to be dredged (i.e., potentially affected aquatic bed habitat) in each River Section.

At each sampling station, nine samples will be collected, for a total of 468 samples. The use of nine samples per station provides flexibility in the design so that multiple strata within each station can be sampled with replication. The specific sample points will be selected to best characterize the strata within the station. The overall sample design combines judgmental and stratified random sampling (USEPA, 2000) into a comprehensive design for characterizing aquatic bed habitats.

For the purposes of the HDA Work Plan, data collected during the limited August 2002 field study (Exhibit B-1) were analyzed to determine the statistical resolution of the proposed sampling design. During the August 2002 study, each sampling station consisted of three transects, with three quadrats per transect (n=9), randomly located in SAV beds of various sizes.

Data were analyzed using non-parametric statistical comparisons (statistical program output below), visual comparisons (graphs below), and calculated relative width of confidence intervals (Exhibit B-2) to determine the resolution of the data. The relative width of confidence intervals is the width of the confidence interval expressed as a percentage of the mean. The confidence interval endpoints are the mean plus or minus this percentage of the mean. The confidence interval analyses indicate that reported mean values are within approximately ±35 to 39% of actual values for the 95th percentile confidence interval, which is an acceptable resolution to meet the program objectives.

In making these comparisons, significant differences were observed between stations, indicating the sample size of 9 is sufficient to detect statistically significant differences in above-ground biomass, percent cover, and shoot density. The ability to detect meaningful differences between stations will provide useful information for the habitat replacement and reconstruction program (e.g., planting density).

Substrate measurements collected as part of the SSAP will also be used to characterize the aquatic bed habitat. These measurements include bulk density, water content, USCS classification, grain size distribution, Atterberg limits, specific gravity, and total organic carbon (see QEA, 2002). As described above, SSAP sample locations will be included on the habitat delineation maps to indicate where SSAP samples were collected in SAV habitat, and additional sediment samples will be collected as necessary to adequately characterize the SAV areas.

IV. Methods

The protocols described in this SOP address both field and laboratory methods. Field and laboratory analyses will be conducted by trained, experienced personnel.

A. Field

Following the collection of aerial photographs (anticipated to be July) and digitization, mapping and ground-truthing of the aquatic beds, sampling will be conducted during the peak of the SAV growing season, between July 15 and August 30. Shoot density, percent cover, and aboveground biomass will be quantified using 1-m square quadrats taken randomly from within the strata at the location.

Plant characteristics, sediment nutrient availability, light availability, current velocity data and wildlife observation data will be collected as distinct tasks using the following protocols.

Plant Characteristics

1. Using SCUBA or snorkeling equipment, collect samples from within sampling quadrats randomly placed within each stratum.
2. Record the center of each sampling quadrat using DGPS.
3. Visually estimate percent cover of the 1-m square quadrat and record in field book.
4. Randomly select two 25 cm x 25 cm subquadrats of the 1-m quadrat. Remove all aboveground material by clipping and store in a pre-labeled sealable bag.
5. Place sample in cooler for transport to the laboratory for processing for shoot density and aboveground biomass.
6. Repeat observations on percent cover at one sampling point per station using different crew member and compare observations. Stations where repeated observations deviate from original estimates by 20% or more will be reassessed.

Sediment Nutrient Availability

1. Using SCUBA or snorkeling equipment, collect surface sediment sample from the center of one randomly selected quadrat from each stratum used for collecting plant characteristic data using a PVC coring tube. Follow Steps 3-7. If the sediment depth is less than 5 cm or presence of large-diameter substrate prevents the collection of a sediment core, proceed to Step 2.
2. Lower a ponar grab from the boat and collect a sample from the center of the quadrat. Retrieve the grab and place on deck. Subsample the collected material to obtain sufficient quantity to fill a PVC tube. Place caps on ends of tube and proceed to Step 5.
3. Remove both end caps from a 2-inch diameter PVC tube, press tube into substrate approximately 12 cm. Place cap on top of tube and slowly extract core from substrate. If necessary, place a dive knife or small shovel under the PVC tube to prevent the sample from falling out as the tube is extracted.
4. Place cap on bottom of tube. Bring to surface and once above surface water, place in holder until any suspended material has settled, then decant excess water from top of tube. Wipe excess water from tube and seal both ends with tape.

5. Place label on tube indicating location, transect number, quadrat number, and date.
6. Place tube in sealable bag and store on ice in cooler.
7. Ship collected samples to the laboratory for processing (by methods provided in Barko et al., 1988).

Light Availability and Water Depth

1. Handheld equipment for measuring photosynthetically active radiation (e.g., Licor 1400 photometer) will be maintained and calibrated in accordance with the manufacturer's instructions. This equipment will be operated from the boat. The air (surface light) and underwater sensors will be attached to the data logger in accordance with the manufacturer's instructions. The underwater sensor will be attached to the sensor platform in accordance with the manufacturer's instructions.
2. Place air sensor on level surface in full sunlight.
3. Outside the deep edge of the bed, lower the sensor platform into the water to a depth of 0.5 m. Record air (surface) and underwater light readings.
4. Lower the calibrated sounding line to the bottom. Record water depth to the nearest centimeter.
5. Lower the sensor platform to a depth of 1 m. Record air (surface) and underwater light readings.
6. Move to the approximate center of the SAV bed, and repeat Steps 3 (at placement of the meter) and5.
7. Lower the calibrated sounding line to the bottom. Record water depth to the nearest centimeter.

Current Velocity

1. Collect velocity data from outside and within the SAV bed using an electromagnetic velocity meter. The instrument will be maintained and calibrated in accordance with the manufacturer's instructions. This equipment will be operated from the boat. The meter will be secured to a long metal or PVC pole to allow raising and lowering of the meter in the water. The pole will be marked at 10 cm and 1 m intervals from the bottom.
2. Orient the meter head directly parallel with the flow. Flagging or streamers (e.g., from cassette tape material) should be tied to the vertical rod to assist with orientation of the meter.
3. Outside the deep edge of the bed, place the meter 10 cm above the substrate. Record velocity.
4. Raise the meter to 1 m above the substrate. Record velocity.
5. Move to the approximate center of the SAV bed and repeat Steps 3 (at placement of the meter) and 4.

Wildlife Observations

1. When on station, qualified topside personnel shall survey the surrounding aquatic bed to document the occurrence or signs of wildlife species that can be observed (e.g., diving ducks).
2. In-water personnel shall survey the area of aquatic bed being sampled for the occurrence or signs of in-water wildlife species, such as mussels, snails, or vertebrates (e.g., turtles).
3. Record observations, including a qualitative narrative synopsis, on Table E-1 provided in Attachment E to the HDA Work Plan.

B. Laboratory

The following tasks will be performed by a contract laboratory.

Vallisneria americana (adapted from Biernacki and Lovett-Doust, 1997)

1. Rinse plants with tap water.
2. Carefully remove and discard invertebrates, algae, etc. from blades.
3. Sort out unattached blades or root mass material not part of an intact shoot.

4. Count the number of intact shoots, and record total number. This number will be used to calculate shoot density.
5. Remove trace belowground material if present.
6. Place all aboveground material (e.g., shoots, blades etc.) in pre-labeled tin foil bag.
7. Refrigerate at cool temperature until drying.
8. Clean and dry glass 1 liter (L) beakers to be used for drying the samples.
9. Determine and record the tare weight of each beaker using precision scale. Mass should be recorded to the nearest 1/100th of a gram.
10. Use scale to record the initial mass of the sample in the beaker before beginning the drying procedure.
11. Place the samples in the laboratory oven for 24 hours at 85 (+/- 1) °C. Confirm that the oven is connected to ventilation system through use of flexible ductwork.
12. Remove samples at the end of 24-hours and place in the desiccator for approximately 45 minutes to confirm the complete removal of water from the samples and to allow for cooling of the sample to room temperature.
13. Record the mass of the samples immediately after removal from the desiccator.
14. Return the samples to the oven for 1 hour, place in desiccator and record the mass for constant mass reading (within 5% of the previous measurement).
15. Repeat Step 14 until constant mass is reached.
16. Place samples in sealed bags for archiving and store at room temperature.

Other Species (each species will be processed separately)

Follow the procedures described above for *Vallisneria americana*, with the following exception. In Step 4, count and record the number of primary stems for each species present.

Sediment Nutrient Analysis (Barko et al., 1988)

1. Remove end caps from tube and extrude 10 cm of material through the top of the tube into a clean glass container.
2. Thoroughly homogenize sample with Teflon coated mixing spoon (or similar).
3. For extractable P: Mix (by shaking) 2 grams of wet sediment with 25 milliliters (ml) of extractant containing 0.3 N NH_4F and 0.025 N HCl for 1 minute. Proceed to Step 6.
4. For exchangeable ammonium-N and K: Mix (by shaking) 5 grams of wet sediment with 50 ml of an extractant containing 1 M NaCl for 1 minute. Proceed to Step 6.
5. For moisture content: follow steps 5-12 in the *Vallisneria americana* procedures above, substituting 250 mL beakers for the 1 L beakers, and using approximately 2 grams of sediment as the sample.
6. Filter extract. Acidify with HCl to pH of 2.0.
7. Use flow-injection analysis procedure for Lachat Quik-Chem Auto-Analyzer (or similar autoanalysis technique) to determine concentrations of extracted nutrients.
8. Express nutrient concentrations on basis of sediment dry mass following correction for moisture content.

C. Development of FCIs

As discussed in Section I, the specific measurements described above will be used to develop FCIs for each function listed in Table B-1 (above) and each station sampled. The FCIs for the fish habitat function may include HSIs for representative indicator species. The approach to be used to develop the FCIs will follow the same general approach used by Ainslie et al. (1999), Smith and Wakeley (2001), and Findlay et al. (2002) and/or, for the fish habitat function, may use pre-existing HSI models. HSI information for selected indicator species will be obtained from http://www.nwrc.usgs.gov/wdb/pub/hsi/hsiindex.htm. Preliminary FCI models and the lists of species for which HSIs will be calculated will be provided in the *Habitat Delineation Report*. The specific methods used will be described, together with the underlying data and the FCI results, in the *Habitat Assessment Reports* referenced in the HDA Work Plan.

V. References

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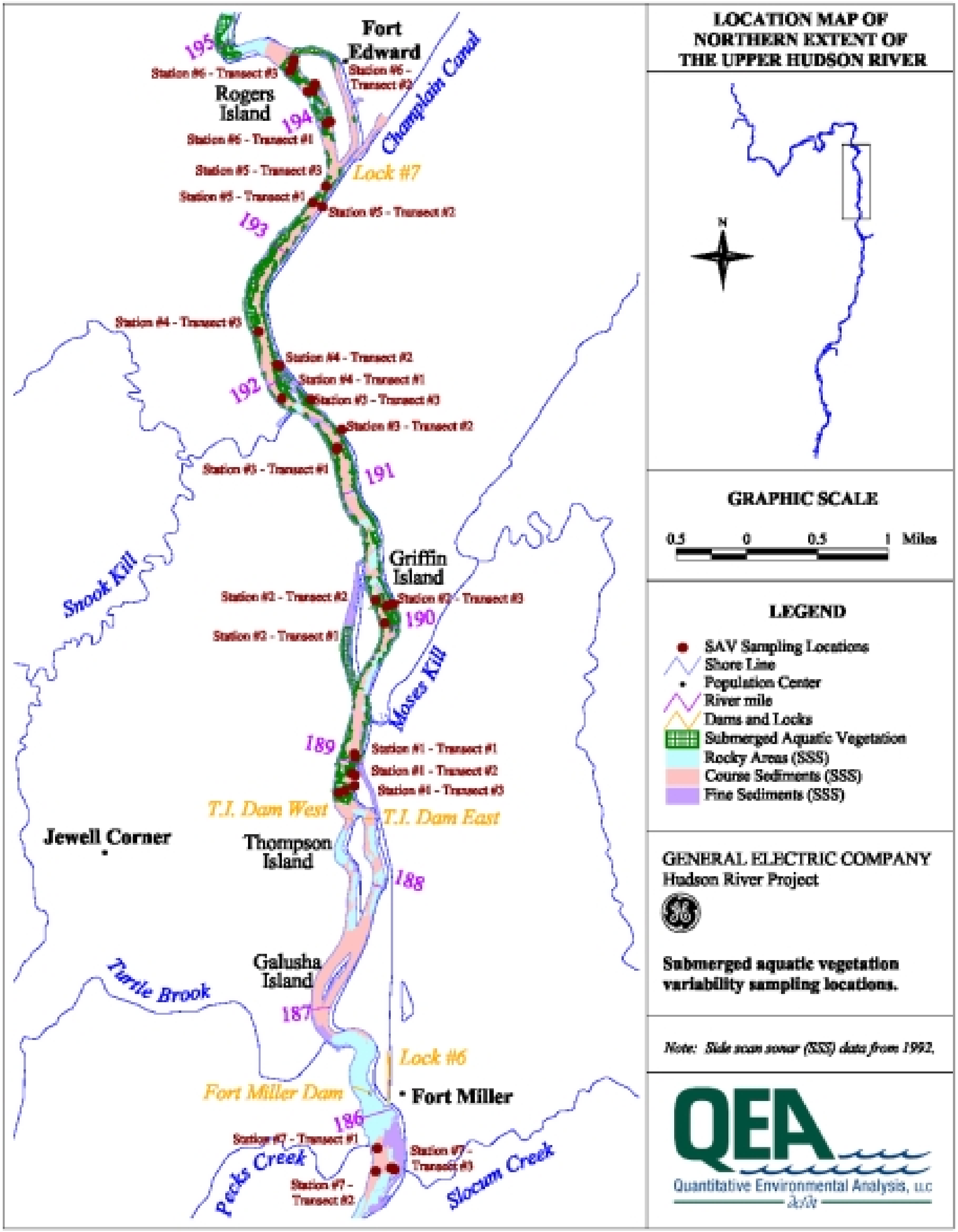


LOCATION MAP OF NORTHERN EXTENT OF THE UPPER HUDSON RIVER

Submerged aquatic vegetation variability sampling locations.

Note: Side scan sonar (SSS) data from 1992.

Figure B-1

Exhibit B-1
Data Collected from Aquatic Beds in the Upper Hudson River (August 2002)

											Light				Current	
											1M		0.5M			
Date	Station	Transect	Depth	Spp	Final Dry Weight (g)	Comments	# of Shoots	Depth (m)	Cover (%)	Distance from Shore (m)	Air	Water	Air	Water	1M (ft/s)	Bottom (ft/s)
8/5/2002	1	1	Shallow	Va	0	No biomass collected	0	0.2	0	0						
8/5/2002	1	1	Middle	Va	5.33	x	18	0.99	95	0						
8/5/2002	1	1	Middle	Other	0.02	x	3	0.99	95	0						
8/5/2002	1	1	Deep	Va	8.02	x	27	2.01	75	0		340		435	0.07	0.08
8/5/2002	1	2	Shallow	Va	5.62	x	14	0.65	50	0						
8/5/2002	1	2	Middle	Va	6.48	x	36	1.2	75	0						
8/5/2002	1	2	Deep	Va	9.35	x	10	2.4	50	0		932	--	1154	0.25	0.1
8/5/2002	1	3	Shallow	Va	5.59	East	14	1.75	80	0						
8/5/2002	1	3	Shallow	Va	15.48	West	41	1.45	100	0		270	--	950		
8/5/2002	1	3	Deep	Va	1.99	x	7	2.62	5	0		1605	--	1093	0.52	0.52
8/5/2002	2	1	Shallow	Va	2.44	x	17	0.25	40	1.35		613	--	750		
8/5/2002	2	1	Middle	Va	3.82	x	15	1.42	75	6.75						
8/6/2002	2	1	Middle	Other	0.11	x	8	1.42	75	6.75						
8/5/2002	2	1	Deep	Va	3.58	x	8	2.25	40	13.5						
8/5/2002	2	2	Shallow	Va	0.97	x	8	0.37	50	1.37				528	--	0.07
8/6/2002	2	2	Middle	Va	12.58	x	7	1.55	100	6.85						
8/6/2002	2	2	Middle	Other	1.98	x	10	1.55	100	6.85						
8/6/2002	2	2	Deep	Va	8.57	x	23	2.53	70	13.7					0.06	0.08
8/6/2002	2	3	Shallow	Va	27.43	x	59	2.3	95	52.2	1601	965	1625	1194	0.49	0.44
8/6/2002	2	3	Middle	Va	10.24	x	40	1.78	50	85.95						
8/6/2002	2	3	Deep	Va	7.33	x	45	1.78	60	131.67	501	253	914	415	0.26	0.35
8/5/2002	2	3	Deep	Other	0.78	x	5	1.78	60	131.67	501	253	914	415	0.26	0.35
8/6/2002	3	1	Shallow	Va	2.64	x	27	0.72	85	7						
8/6/2002	3	1	Shallow	Other	0.02	x	5	0.72	85	7						
8/6/2002	3	1	Middle	Va	0.27	x	5	1.8	80	30.17	1790	737	1767	1221	0.36	0.15
8/6/2002	3	1	Middle	Other	15.7	x	10	1.8	80	30.17	1790	737	1767	1221	0.36	0.15
8/6/2002	3	1	Deep	Va	6.98	x	47	2.3	70	42.06	811	25	2005	631	0.36	0.3
8/6/2002	3	2	Shallow	Va	2.36	x	11	0.28	40	5.4			1440	789	--	0
8/6/2002	3	2	Shallow	Other	0.48	x	3	0.28	40	5.4			1440	789	--	0
8/8/2002	3	2	Middle	Va	10.2	x	23	0.86	45	9.7						
8/6/2002	3	2	Middle	Other	0.17	Fragments contribute to biomass	1	0.86	45	9.7						
8/6/2002	3	2	Deep	Va	22.24	x	5	1.32	50	14.1						

Exhibit B-1
Data Collected from Aquatic Beds in the Upper Hudson River (August 2002)

Date	Station	Transect	Depth	Spp	Final Dry Weight (g)	Comments	# of Shoots	Depth (m)	Cover (%)	Distance from Shore (m)	Light				Current	
											1M		0.5M		1M (ft/s)	Bottom (ft/s)
											Air	Water	Air	Water		
8/8/2002	3	3	Shallow	Va	10.69	West	38	0.85	100	7.1						
8/8/2002	3	3	Shallow	Other	0.07	West/Biomass are frags	0	0.85	100	7.1						
8/8/2002	3	3	Shallow	Va	5.22	East	17	0.53	70	0.54						
8/8/2002	3	3	Middle	Va	2.93	x	14	1.42		24.69	1449	685	1545	1143	0 (out of bed)	0.19 (in bed)
8/8/2002	3	3	Middle	Other	0.4	x	10	1.42		24.69	1449	685	1545	1143	0 (out of bed)	0.19 (in bed)
8/8/2002	4	1	Shallow	Va	6.77	x	33	0.49	70	7.9						
8/8/2002	4	1	Shallow	Other	0.32	Fragments contribute to biomass	1	0.49	70	7.9						
8/8/2002	4	1	Middle	Va	2.35	x	14	1.26	75	0						
8/8/2002	4	1	Deep	Va	42.99	x	97	2.3	80	22.86	1781	680	1744	1213	0.89 (out of bed)	1.25 (out of bed)
8/8/2002	4	2	Shallow	Va	3.85	x	69	0.75	80	8.7						
8/8/2002	4	2	Middle	Va	3.66	x	30	1.8	60	23.77	2027	738	2036	1149		
8/8/2002	4	2	Deep	Va	18.71	x	95	1.63	100	56.69	2075	334	2027	846	0.22 (out of bed)	0.17 (out of bed)
8/8/2002	4	3	Shallow	Va	4.25	x	37	1.33	35	12.8						
8/8/2002	4	3	Middle	Va	5.87	x	39	1.7	60	28.35						0 (out of bed)
8/8/2002	4	3	Deep	Va	17.83	x	69	1.82	85	36.58	1330	797	2026	1453	0 (out of bed)	0.14 (out of bed)
8/8/2002	4	3	Deep	Other	0.66	Biomass are frags	0	1.82	85	36.58	1330	797	2026	1453	0 (out of bed)	0.14 (out of bed)
8/8/2002	5	1	Shallow	Va	2.03	x	10	0.5	50	5.3						
8/8/2002	5	1	Middle	Va	12.34	x	41	0.95	55	6.7	1790	125	1665	391		0
8/8/2002	5	1	Middle	Other	0.07	Biomass are frags	0	0.95	55	6.7	1790	125	1665	391		0
8/8/2002	5	1	Deep	Va	4.47	x	8	1.92		8.5						
8/8/2002	5	2	Shallow	Va	0.28	x	5	0.009	5	1.9						
8/8/2002	5	2	Middle	Va	1.72	x	18	0.2	25	3.6						
8/8/2002	5	2	Middle	Other	0.31	x	1	0.2	25	3.6						
8/8/2002	5	2	Deep	Va	3.85	x	29	0.7	70	5.4	1841	460	2266	1320	0.14 (out of bed)	0.25 (out of bed)
8/8/2002	5	3	Shallow	Va	2.96	x	14	0.11	40	3.6						
8/8/2002	5	3	Middle	Va	13.01	x	33	0.52	100	5.4						
8/8/2002	5	3	Deep	Va	3.62	x	27	1.8	70	7.7			700	332	0 (out of bed)	0.24
8/8/2002	6	1	Shallow	Va	3.98	West	15	1.72	95	40.23					0.24 (out of	0.14 (out of

Exhibit B-1
Data Collected from Aquatic Beds in the Upper Hudson River (August 2002)

Date	Station	Transect	Depth	Spp	Final Dry Weight (g)	Comments	# of Shoots	Depth (m)	Cover (%)	Distance from Shore (m)	Light				Current	
											1M		0.5M			
											Air	Water	Air	Water	1M (ft/s)	Bottom (ft/s)
															bed)	bed)
8/8/2002	6	1	Middle	Va	7.99	x	22	1.7	100	61.26	1366	270	1345	1141		
8/8/2002	6	1	Shallow	Va	4.32	East	38	0.95		61.26	1445	978	1445	581	0.58 (out of bed)	0.72 (out of bed)
8/8/2002	6	2	Shallow	Va	6.66	East	17	0.86	100	8.3	1748	971	1760	1398		
8/8/2002	6	2	Shallow	Other	0.42	East/Biomass are frags	0	0.86	100	8.3	1748	971	1760	1398		
8/8/2002	6	2	Middle	Va	8.36	x	43	1.26	100	0					1.3 (out of bed)	1.4 (out of bed)
8/9/2002	6	2	Shallow	Va	12.76	West	29	1.05	100	138.07	1131	820	1751	1042	1.23 (out of bed) 0.7 (in bed)	1.04 (out of bed) 0.75 (in bed)
8/8/2002	6	3	Shallow	Va	3.44	West	12	0.65	75	11			1818	921		0.3 (out of bed)
8/8/2002	6	3	Middle	Va	3.07	x	31	1.37	75	122.53	1764	813	1778	1204	1.5	2
8/8/2002	6	3	Middle	Other	0.81	x	5	1.37	75	122.53	1764	813	1778	1204	1.5	2
8/8/2002	6	3	Shallow	Va	1.67	East	20	0.6	75	64			1902	1528	--	1.41 (out of bed)
8/8/2002	6	3	Shallow	Other	1.82	East	6	0.6	75	64			1902	1528	--	1.41 (out of bed)
8/8/2002	7	1	Shallow	Va	4.69	x	22	0.8	100	9.8						
8/8/2002	7	1	Middle	Va	5.18	x	29	0.58	80	31.09						
8/8/2002	7	1	Deep	Va	2.8	x	17	1.95	100	37.49			1188	780	0.45 (out of bed) 0.25 (in bed)	0.8 (out of bed) 0.04 (in bed)
8/8/2002	7	2	Shallow	Va	2.55	x	18	0.12	85	6						
8/8/2002	7	2	Shallow	Other	0.7	x	7	0.12	85	6						
8/8/2002	7	2	Middle	Va	0.55	x	9	0.62	35	32.92			1444	736	0	0
8/8/2002	7	2	Deep	Va	3.47	x	19	1.18	95	41.15						
8/8/2002	7	3	Shallow	Va	0.64	x	13	0.12	65	4.2			1353	1092	--	0
8/8/2002	7	3	Middle	Va	6.3	x	22	1.08	60	36.58						
8/8/2002	7	3	Deep	Va	9.74	x	31	0.25	70	61.26						

Exhibit B-2

SIGNIFICANCE TESTS FOR CORRELATIONS BETWEEN SAV AND STATION PARAMETERS

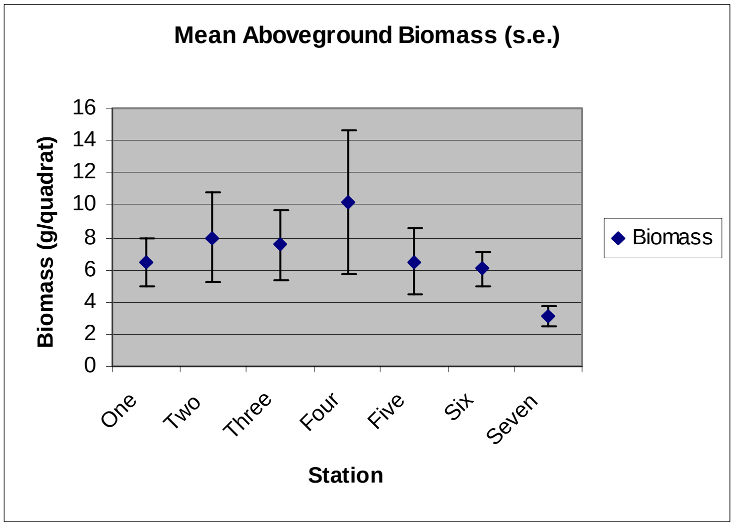
Spearman's rank correlations:

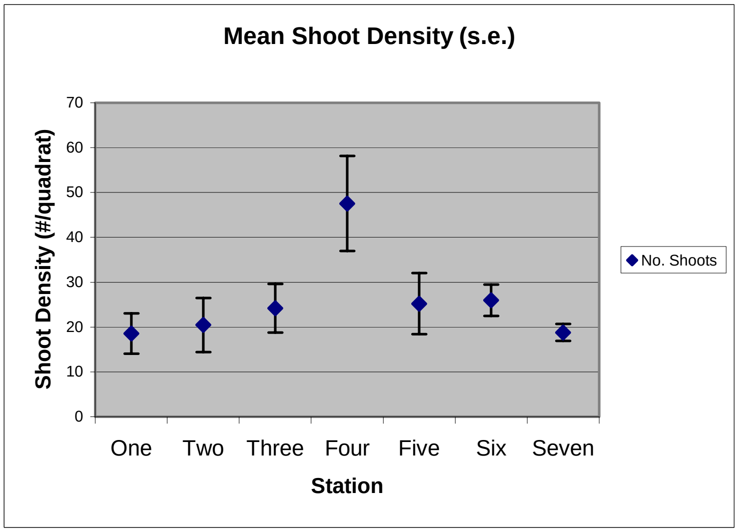
Biomass and Depth
normal-z = 2.988, p-value = **0.0028** **SIGNIFICANT RELATIONSHIP** ($p<0.05$)
NoShoots and Biomass
normal-z = 4.7324, p-value = **0.0** **SIGNIFICANT RELATIONSHIP** ($p<0.05$)
CoverPct and Biomass
normal-z = 3.2799, p-value = **0.001** **SIGNIFICANT RELATIONSHIP** ($p<0.05$)
NoShoots and Depth
normal-z = 1.4699, p-value = **0.1416** NO SIGNIFICANT RELATIONSHIP ($p>0.05$)
CoverPct and Depth
normal-z = 1.4184, p-value = **0.1561** NO SIGNIFICANT RELATIONSHIP ($p>0.05$)

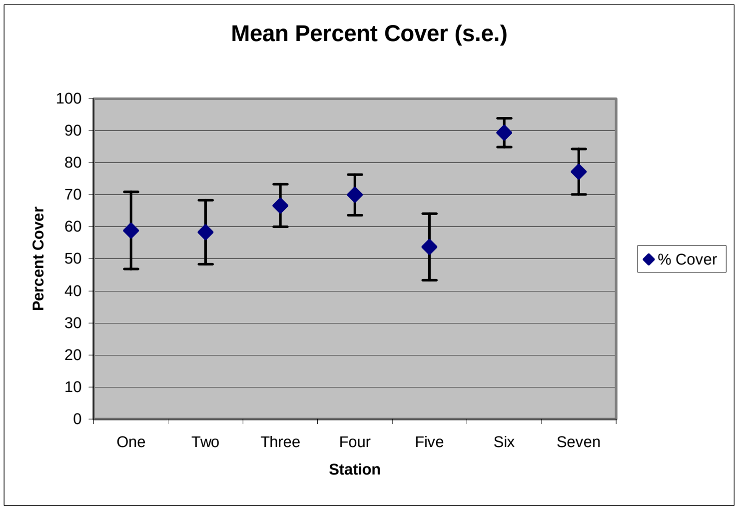
EVALUATE DIFFERENCES BETWEEN STATIONS (See Graphs Below)

Kruskal-Wallis rank sum test

NoShoots and Station
Kruskal-Wallis chi-square = 12.3977, df = 6, p-value = **0.0537** **SIGNIFICANT DIFFERENCE** ($p<0.10$)
CoverPct and Station
Kruskal-Wallis chi-square = 11.6572, df = 6, p-value = **0.0701** **SIGNIFICANT DIFFERENCE** ($p<0.10$)
Biomass and Station
Kruskal-Wallis chi-square = 4.9662, df = 6, p-value = **0.5482** NO SIGNIFICANT DIFFERENCE ($p>0.10$)




Mean Shoot Density (s.e.)
Shoot Density (#/quadrat)
70
60
50
40
30
20
10
0
One
Two
Three
Four
Five
Six
Seven
Station
◆ No. Shoots


Mean Percent Cover (s.e.)
Percent Cover
100
90
80
70
60
50
40
30
20
10
0
One
Two
Three
Four
Five
Six
Seven
Station
◆ % Cover

	Relative Width of Conf.Limits		
	90%	95%	99%
Dry Weight [a]			
Station1	35%	42%	58%
Station2	31%	37%	52%
Station3	37%	44%	62%
Station4	30%	36%	50%
Station5	38%	45%	63%
Station6	22%	26%	36%
Station7	35%	41%	57%
Shallow	18%	20%	27%
Middle	18%	21%	27%
Deep	20%	23%	29%
All Samples (n=63)	11%	12%	16%
Station Avg (n=9)	33%	39%	54%
No. of Shoots [b]			
Station1	38%	45%	63%
Station2	31%	37%	51%
Station3	29%	34%	48%
Station4	23%	27%	38%
Station5	26%	30%	42%
Station6	17%	20%	27%
Station7	14%	17%	23%
Shallow	23%	27%	35%
Middle	13%	15%	19%
Deep	16%	18%	23%
All Samples (n=63)	10%	11%	14%
Station Avg (n=9)	29%	35%	48%
Percent Cover [c]			
Station1	44%	52%	73%
Station2	24%	29%	40%
Station3	24%	29%	41%
Station4	19%	22%	31%
Station5	48%	57%	80%
Station6	33%	39%	54%
Station7	21%	26%	36%
Shallow	22%	25%	33%
Middle	15%	17%	23%
Deep	19%	22%	28%
All Samples (n=63)	10%	12%	15%
Station Avg (n=9)	31%	37%	51%

[a] - ln (Dry Weight +1) transform used

[b] - sqrt (No. of Shoots) transform used

[c] - asin(sqrt(Percent Cover/100)) transform used

Attachment C. Standard Operating Procedure for Natural Shoreline Assessment

I. Objective

The objective of this Standard Operating Procedure (SOP) is to set forth methods to measure the range of existing habitat conditions for natural shorelines within River Sections 1, 2, and 3 of the Upper Hudson River. The assessment activities that will be performed are described generally in Section 2.2.3.2 of the *Habitat Delineation and Assessment Work Plan* (HDA Work Plan; Blasland, Bouck & Lee, Inc. [BBL], 2003) for the Upper Hudson River. This SOP provides a methodology for collecting information to document the range of conditions in the natural shoreline habitats as they currently exists along the Upper Hudson River. (Note that this SOP does not address maintained shorelines, which will be addressed during remedial design.)

Measurements described in this SOP are based on characteristics of habitat structure. Habitat structure is defined as the physical components and the organization or pattern of a habitat, community or ecosystem. Habitat structure and ecological functions are intrinsically linked, and in general, when there is suitable habitat structure, aquatic communities and associated ecosystem functions are present. This approach is consistent with the Record of Decision (ROD) for the Upper Hudson River (United States Environmental Protection Agency [USEPA], 2002) and previous studies that have shown that successful fluvial replacement and reconstruction projects depend mainly on the presence of suitable physical habitat (e.g., Gore, 1985). Although the approach in the ROD (Responsiveness Summary, page 9-33) is specific to river bottoms, an adaptation of this approach is both applicable and relevant to shorelines.

The functions to be assessed for the natural shoreline habitats, the specific measurements to be taken in the field to quantify those functions, and a brief rationale for their measurement are shown in Table C-1. The measurements will be used to develop functional capacity indices (FCIs) for the natural shoreline habitats, so as to allow for management decisions regarding reallocation of functions among the replaced and reconstructed habitats, if necessary. FCIs are values calculated from the field measurements that provide a synthesis of information for evaluating habitat functions - in this case, the functions listed in Table C-1. FCIs provide a site-specific basis for describing the functional capacity of a habitat at a specific location, and for comparing functional capacity among locations. For the wildlife habitat function, pre-existing Habitat Suitability Indices (HSIs) for specific representative indicator species may be used in addition to or in lieu of FCIs. Otherwise, project-specific FCI models will be developed. The conceptual foundations for the application of project-specific FCIs are discussed generally in Ainslie et al. (1999) and Smith and Wakeley (2001), and specifically for the Hudson River in Findlay et al. (2002). While these studies address riverine wetlands, the overall approach to developing and using FCIs is applicable to and will be used for characterizing natural shoreline habitats.

Table C-1. Shoreline

Function	Measured Variable	Rationale
Shoreline Stability	Downfall (trees/m2) Bank stability Bank vegetation protection	Large trees armor bank against scour Stable banks less likely to slump, fail Presence indicates longer term stability
Shade and Cover	Downfall (trees/m2) Bank vegetation protection Riparian edge cover	Provides in-water cover; organic food source Overstory provides shade, thermal cooling Cover for wildlife accessing shoreline
Wildlife Habitat (Habitat suitability)	Downfall (trees/m2) Bank stability Bank vegetation protection Riparian edge cover	Provides in-water cover; organic food source Less open areas; ease of access to water Shade and cover for access Protection from predation between access points

FCIs will be developed for each function listed in Table C-1 and each station sampled (as described in Section III below). These FCIs, together with the underlying data, associated maps (as necessary), and the specific protocols used to develop the FCIs, will be presented to USEPA in the *Habitat Assessment Reports* referenced in the HDA Work Plan.

II. Necessary Materials and Equipment

- Small boat with standard water safety gear (e.g., personal flotation device [PFD]; first aid kit)
- Protective gear for working in water (e.g., hip waders, wetsuit, drysuit)
- Foul weather gear
- Rapid Bioassessment Protocols (RBP) guidance document
- Differential Global positioning system (DGPS) unit
- Soil auger
- Inclinometer
- Video camera
- Survey measuring tape (100-meter [m] length is recommended)
- Erasable slate with pens
- Binoculars
- Field guide(s)
- Field log book

III. Sampling Design

As described in the HDA Work Plan, natural shoreline habitats will be delineated and mapped based on aerial photographs (primarily oblique photography), field ground-truthing, and, as appropriate for adjacent shallow river bottoms, side-scan sonar output and substrate characterization data from the Sediment Sampling and Analysis Program (SSAP). As a component of habitat delineation activities, this information will be integrated into a series of overlay habitat delineation maps. These maps will be used to identify a suite of sampling strata for the detailed assessment of natural shoreline habitats. Strata will be based on one or more key parameters relevant to shoreline habitats, such as substrate type, dominant vegetation, bank slope, adjacent land use, and others as appropriate.

River Sections 1, 2, and 3 together comprise about 40 river miles (64 kilometers), or 80 bank miles (128 bank kilometers) from the former Fort Edward Dam to the Federal Dam at Troy. From oblique aerial photography and subsequent ground-truthing, the entire 80 miles of bank habitat will be delineated and classified into habitat strata. However, only a portion of that overall bank habitat will be affected by remedial activities. According to the USEPA ROD Responsiveness Summary (ROD Part 3; Book 1 of 3, at page 4-29 and at page 10-23, USEPA, 2002), it appears that a total of approximately 17 miles of shoreline may be subject to remediation impacts (including both natural and maintained shorelines). The detailed functional habitat assessment activities will be conducted at representative sampling stations in natural shoreline habitats, with the goal of conducting such activities at an average distribution of approximately two stations per mile of potentially impacted river bank habitat (based on professional judgment), with a corresponding number of reference stations along non-impacted river banks. To achieve this goal, a total of 68 stations will be selected for the detailed functional assessment of natural shorelines. These stations will be selected, using the information from the habitat delineation maps, together with available information on areas to be dredged, so as to meet the following criteria:

1. Adequately characterize all the natural shoreline habitat strata identified from the habitat delineation information, as described above;

2. Include a roughly equivalent number of target stations (in dredge areas) and reference stations (in non-dredge areas); and

3. Be allocated among River Sections in rough proportion to the relative areas of natural shoreline habitats likely to be affected in each River Section.

At each station, three transects will be established and sampled to assess habitat characteristics of the natural shorelines. Thus, the overall sampling design will involve the sampling of 204 transects, with 102 in target areas and 102 in reference areas. The specific transect locations to be sampled will be selected to best characterize the shoreline strata within the station and based on the amount of dredging to be completed. Thus, an area of uniform natural shoreline or where limited dredging is planned will receive fewer sample points than an area of heterogeneous natural shoreline or where more extensive dredging is planned.

IV. Methods

The protocols described in this SOP for assessing river bank habitat are adapted from the USEPA RBPs (Barbour et al., 1999). Sampling will be conducted by trained, experienced personnel (per Barbour et al., 1999). Sample locations will not be disturbed by sampling personnel prior to making habitat parameter estimates.

Five methods will be used to assess shoreline habitats: A) videotape monitoring; B) shoreline substrate assessment; C) river bank assessment; D) riparian edge vegetation assessment; and E) limited wildlife observations. Each method will be implemented along pre-established transects. Videotape documentation will provide descriptive information on shoreline habitats. Substrate assessment, river bank assessment, and riparian edge vegetation assessment will provide quantitative habitat characterization information. The specific procedures for each method are described below.

Following the collection of oblique photographs (anticipated to be in July) and digitization, mapping and ground-truthing of the shoreline habitat, sampling will be conducted between June 1 and September 30 so that riparian edge vegetation can be identified and percent cover estimates determined. As stated in Section 2.1.3, adjacent areas will be qualitatively categorized into different landscapes (e.g., agricultural land, grassland, floodplain, forested, emergent wetland, etc.) and the width of the riparian zone will be determined to the extent allowed by the photography.

A. Videotape Monitoring Protocol

1. Locate transect position as determined from station location distribution described in Section III. Start offshore, in shallow water, approximately 3.0 m from the shoreline (it may be necessary to locate this position from a boat in areas where the riverbed is steeply sloped). Record precise transect location with DGPS.

2. Have one person remain at the point recorded in Step 1. Direct second person to walk perpendicular to shore with zero end of surveyor's tape. Advance to the top of the river bank slope, or 2.0 meters from the water's edge (whichever is a shorter distance). Have second person record location with DGPS. Have first person record length.

3. Starting from shallow water, position videotape downstream. Write transect number, date, and "downstream" on erasable slate. Record information on slate, remove from camera view, and proceed along transect from shallow water to riparian edge. Keep camera view positioned downstream throughout transect. End recording.

4. Repeat Step 3 (replacing the term "downstream" with "upstream") for upstream recording.

5. End videotaping.

B. Shoreline Substrate Assessment Protocol

1. At each transect, establish position at shoreline (e.g., edge of water line) and record location in field notebook (distance from riparian edge DGPS location).

2. As described by Barbour et al. (1999), visually observe the river surface substrate in an area from approximately 3.0 m offshore (this distance may be less in areas where the riverbed is steeply sloped) to the river bank "slope," or where terrestrial vegetation begins to cover the substrate. Use Table C-2 to record the approximate percent composition of inorganic features of the shoreline substrate in the inspected area determined by visual/tactile observation.

Table C-2. Inorganic Shoreline Substrate Components

Substrate Type	Diameter (millimeters [mm])	Percent Composition (0-100%)
Bedrock		
Boulder	> 256 mm (10 inches)	
Cobble	64 – 256 mm (2.5 – 10 inches)	
Gravel	2 – 64 mm (0.1 – 2.5 inches)	
Sand	0.06 – 2 mm (gritty)	
Silt	0.004-0.06 mm	
Clay	<0.004 mm (slick)	

(Adapted from Barbour et al., 1999)

3. As described by Barbour et al. (1999), use Table C-3 to record the percent composition of organic features of the shoreline substrate in the same visually inspected area as noted in Step 2.

Table C-3. Organic Shoreline Substrate Components		
Substrate Type	**Characteristic**	**Percent Composition (0-100%)**
Detritus	Sticks, wood, course plant material (CPOM)	
Muck-Mud	Black, very fine organic (FPOM)	
Marl	Grey, shell fragments	
Vegetated	Submerged or emergent vegetation present	

(Adapted from Barbour et al., 1999)
Note: Values are recorded visually and are therefore approximations

4. As modified from Barbour et al., (1999), record the estimated length and width of large woody debris formations in direct contact with the water surface within 50 meters on either side of the transect line. Individual limbs or logs are included if their diameter is 10 cm or greater. Multiply the length and width of the formations to obtain an estimate of downfall/m^2 (area sampled).

5. Repeat observations at one sampling point per station using different crew member and compare observations. Stations where repeated observations deviate from original estimates by 20% or more will be reassessed.

C. River Bank Assessment Protocol

1. At each transect, establish position in transect at base of river bank. Record location in field notebook (distance from riparian edge DGPS location). The river bank starts where a sharp rise in slope from the shoreline is obvious, or where terrestrial vegetation begins to cover the substrate.

2. Record relative slope of bank (using inclinometer or survey data if available).

3. As described by Barbour et al. (1999), estimate the percent of bank erosion by visual observation of freshly exposed substrate and unvegetated soils and sediments and use Table C-4 to determine and record estimated stability.

Table C-4. Bank Assessment Components	
Stability	**Percent Bank Erosion**
Stable – banks stable; evidence of erosion or bank failure absent or minimal	< 5%
Moderately Stable – infrequent small areas of erosion mostly healed	5 - 30%
Moderately Unstable – areas of erosion present, unhealed	30 – 60%
Unstable – eroded areas frequent along straight sections obvious bank sloughing	60 – 100%

(Adapted from Barbour et al., 1999)

4. As described by Barbour et al. (1999), visually estimate the amount of vegetative protection afforded to the river bank. Use Table C-5 to record the percent of the river bank covered by vegetation.

Table C-5. Bank Vegetative Components

Vegetative Protection	Percent River Bank Covered by Vegetation
Optimal – river bank surfaces and immediate riparian zones covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption minimal	> 90%
Suboptimal – river bank surfaces covered by native vegetation but one class of plants not well-represented; disruption evident but not affecting full plant growth potential	70 – 90%
Marginal – vegetative disruption evident; patches of bare soil or closely cropped vegetation common	50-70%
Poor – vegetative disruption is very high; vegetation has been removed to 5 cm or less in average height	< 50%

(Adapted from Barbour et al., 1999)

5. Repeat observations at one sampling point per station using different crew member and compare observations. Stations where repeated observations deviate from original estimates by 20% or more will be reassessed.

D. Riparian Edge Vegetation Assessment Protocol

1. Establish position along each transect at riparian edge. The riparian edge is defined, for purposes of the Remedial Design Work Plan, as the area at the top of the river bank or 2.0 meters from the water's edge (whichever is a shorter distance). Note this location has been recorded in DGPS (see part A, *Videotape Monitoring*) and the width of the riparian edge was determined from aerial photography. Qualitatively record the adjacent land use based on visual inspection.

2. Visually estimate percent cover for canopy, understory, and herbaceous layer at the riparian edge. Ground-truth riparian edge as defined by aerial photographs. Use Table C-6 to record percent cover and dominant species composition for each layer.

3. Repeat observations at one sampling point per station using different crew member and compare observations. Stations where repeated observations deviate from original estimates by 20% or more will be reassessed.

Table C-6. Riparian Edge – Cover Components		
Vegetation Biome	Percent Cover (0-100%)	Dominant Species Composition
Canopy		
Understory		
Herbaceous		

E. Wildlife Observations

1. When on station, qualified personnel shall survey the surrounding natural shoreline to document the occurrence or signs of wildlife species (e.g., small mammals, birds) on or along those shorelines.

2. Record observations, including a qualitative narrative synopsis, on Table E-1 provided in Attachment E to the HDA Work Plan.

F. Development of FCIs

As described in Section I, the specific habitat parameter results described above will be used to develop FCIs for each function listed in Table C-1 (above) and each station sampled. The FCIs for the wildlife habitat function may consist of HSIs for representative indicator species. The approach to be used to develop the FCIs will follow the same general approach used by Ainslie et al. (1999) and Findlay et al. (2002) and/or, for wildlife habitat, may use pre-existing HSI models. HSI information for selected indicator species will be obtained from http://www.nwrc.usgs.gov/wdb/pub/hsi/hsiindex.htm. Preliminary FCI models and the lists of species for which HSIs will be calculated will be provided in the *Habitat Delineation Report*. The specific methods used will be described, together with the underlying data and the FCI results, in the *Habitat Assessment Reports* referenced in the HDA Work Plan.

V. References

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Smith, R. D. and J. S. Wakeley. 2001. *Hydrogeomorphic Approach to Assessing Wetland Functions: Guidelines for Developing Regional Guidebooks* -- *Chapter 4, Developing Assessment Models*. ERDC/EL TR-01-30, US Army Engineer Research and Development Center, Vicksburg, MS.

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Attachment D. Standard Operating Procedure for Fringing Wetland Assessment

I. Objective

The objective of this Standard Operating Procedure (SOP) is to set forth methods to measure the range of existing conditions of fringing wetland habitats in River Sections 1, 2, and 3 of the Upper Hudson River. The assessment activities that will be performed are described generally in Section 2.2.4 of the *Habitat Delineation and Assessment Work Plan* (HDA Work Plan; Blasland, Bouck & Lee, Inc. [BBL], 2003). This SOP provides a methodology for collecting information to document the range of conditions in the fringing wetland habitats, using techniques that are adapted from, and combine elements of, the hydrogeomorphic (HGM) assessment methods (Ainslie et al., 1999; Smith and Wakely, 2001; Findlay et al., 2002) and biological measurement techniques (Stevenson and Hauer, 2002; United States Environmental Protection Agency [USEPA], 2002a).

The approach to conducting the wetland functional assessments is based on the understanding that wetland structure and function are intrinsically linked (Niedowski, 2000). In general, when suitable habitat structure exists, biological communities and associated ecosystem functions are present. Measurements described in this SOP are based on characteristics of habitat structure. The approach described in this SOP is consistent with the Record of Decision (ROD) (USEPA, 2002b) and previous studies that have shown that successful fluvial replacement and reconstruction projects depend mainly on the presence of suitable physical habitat (e.g., Gore, 1985). Although the approach in the ROD (Responsiveness Summary, page 9-33) is specific to river bottoms, an adaptation of this approach is both applicable and relevant to wetlands.

The functions to be assessed for the fringing wetlands habitats, the specific measurements to be taken in the field to quantify those functions, and a brief rationale for those measurements are shown in Table D-1. The measurements will be used to develop functional capacity indices (FCIs) for the fringing wetland functions, so as to allow for management decisions regarding reallocation of functions among the replaced and reconstructed habitats, if necessary. FCIs are values calculated from field habitat measurements that provide a synthesis of information for evaluating habitat functions—in this case, the functions listed in Table D-1. FCIs provide a site-specific basis for describing the functional capacity of a habitat at a specific location, and for comparing functional capacity among locations. Development and application of FCIs in riverine wetlands is discussed generally in Ainslie et al. (1999) and Smith and Wakely (2001). A specific application of FCIs for riverine wetlands in the Lower Hudson River is available in Findlay et al. (2002). The development and application of FCIs for fringing wetlands in the Upper Hudson River will be analogous to the approach of Findlay et al. (2002). However, for the wildlife habitat function, pre-existing Habitat Suitability Indices (HSIs) for specific representative indicator species may be used in addition to or in lieu of other FCIs.

Table D-1. Wetlands

Function	Measured Variable	Rationale
Energy Dissipation	Wetland area	Larger wetlands extend along longer shoreline
	Percent wetland edge altered	Intact wetlands buffer wave/current energy better
	Slope	Low slope relates to less reflected energy
	Stem density	Stems dampen wave/current energy
	Stem thickness	Sturdier plants withstand stronger flows
	Stem length	Taller plants protect during higher flows
	Above-ground biomass	Standing stock (or bulk) of material baffling energy
Surface-Water Exchange	Wetland area	Indicates size of surface – water interface
	Presence/fluctuating water table	Indicates potential for infiltration to occur
	Slope	Lower slope relates to longer residence time
Primary Production	Wetland area	Areal extent of productivity
	Above-ground biomass	Shoot biomass surrogate for productivity
Nutrient Cycling	Above-ground biomass	Represents total mass of living organic matter available to enter nutrient cycle
	O Horizon - percent cover	Recognizable dead organic matter and associated decomposers
	A Horizon - percent cover	Unrecognizable dead organic matter entering nutrient cycle. Combined with “O” horizon, indicates nutrients are being recycled.
Remove and Hold Elements/Compounds	Clay content	Clay particles have more binding sites for holding elements
	Redoximorphic features	Indicates that denitrification has occurred
	O Horizon - percent cover	Organic matter available for holding elements / compounds
	A Horizon - percent cover	Combined with “O” horizon, indicates organic matter available for holding elements / compounds
Export Organic Carbon	O Horizon - percent cover	Organic material in surface soil layer that can be readily exported
Maintain Character Plant Community	Plant species composition	Diverse communities more “stable”
	Stem density	Related to area open for colonization
	Above-ground biomass	Indicates relative productivity
Wildlife Habitat (Habitat suitability)	Wetland area	Larger areas support larger communities
	Area of buffer	Allows greater isolation of wetland interior
	Contiguous with other habitats (percent)	Connectivity; emigration; increased foraging opportunities
	Plant species composition	Diverse plant communities can support higher diversity of wildlife
	Stem density	Cover, protection from predation
	Above-ground biomass	Related to primary productivity (food resources)

FCIs will be developed for each function listed in Table D-1 and for each wetland sampled (as described in Section III below). These FCIs, together with the underlying data, associated maps (as necessary), and the specific protocols used to develop the FCIs, will be presented to USEPA in the *Habitat Assessment Reports* referenced in the HDA Work Plan.

II. Necessary Field Materials and Equipment

- Small boat with standard water safety equipment (e.g., personal flotation device [PFD]; first aid kit)
- Foul weather gear
- Chest waders
- Differential Global Positioning System (DGPS) unit
- Soil probe/sharpshooter shovel
- Survey measuring tape
- Diameter tape or calipers for measuring tree diameter at breast height (dbh)
- Stakes and flagging
- Measuring tape (metric, 100 meter [m])
- Plant identification keys
- Munsell color book and hydric soil indicator list
- Sampling quadrats (0.25 square meter [m^2])
- Random number table
- Sealable storage bags, prelabeled
- Laboratory support equipment (e.g., jars, labels, etc.)
- Field log book
- Camera
- Binoculars
- Field guide(s)

III. Sampling Design

As described in the HDA Work Plan, fringing wetland habitats (and backwater wetlands to the extent allowed by the aerial photography) will be identified and mapped based on aerial photographs (including oblique photography), ground-truthing, and existing documentation. Wetlands will be delineated in accordance with the U.S. Army Corps of Engineers *Wetland Delineation Manual* (USACE, 1987). As part of the habitat delineation activities, the information from the aerial photographs and other delineation activities will be integrated into a series of overlay habitat delineation maps. These maps will be used to identify a suite of sampling strata for the detailed fringing wetland assessment activities. These strata will be based on one or more key wetland parameters, such as dominant vegetation, wetland parcel size, and others as appropriate.

Detailed functional assessments will be conducted in representative fringing wetlands greater than 250 square meters (0.06 acre) in areas that are located such that they could be directly affected by remediation activities and in comparable reference wetlands. Sufficient wetlands will be assessed to adequately characterize the functional conditions within wetlands representing each stratum identified during delineation activities.

Findlay et al. (2002) provide a useful model on which to base a sampling design for functional assessment of Upper Hudson River fringing wetlands. In their study of Lower Hudson River wetlands, Findlay et al. assessed wetlands in one hydrogeomorphic class (riverine) and three subclasses (sheltered, fringing, and enclosed). In each subclass, they assessed five wetlands (chosen to reflect the widest possible range of functions), for a total of 15 stations. At each station, they sampled three transects of five quadrats each.

For the Upper Hudson River, fringing wetlands (a single subclass in the riverine hydrogeomorphic class) are subject to direct potential impacts associated with remediation. Thus, by analogy to Findlay et al. (2002), five stations will be selected within this subclass, such that five fringing wetlands greater than 250 square meters in size in areas that will potentially be impacted by remedial activities will be assessed. These wetlands will be selected (from the fringing wetlands identified and delineated during habitat delineation activities) so as to reflect the broadest range of functions (within that hydrogeomorphic class of wetlands) and so as to adequately characterize the wetland habitat strata identified from the delineation information (as described above). In addition, five fringing wetlands of generally similar size and range of functions will be selected in areas that are not adjacent to potentially impacted areas (reference wetlands). In the event that other wetlands from other subclasses (e.g., sheltered) are identified as being directly impacted by the remediation activities, those wetlands will be evaluated consistent with the current sampling design for fringing wetlands.

Within each wetland, three transects will be established for appropriate measurements, and along each transect, three quadrats will be located for sampling of appropriate parameters. Three quadrats will be used, rather than five as used by Findlay et al. (2002), because: 1)fringing wetlands in the Upper Hudson are smaller than those in the Lower Hudson; and 2) the quadrats used by Findlay et al (2002) were $0.25m^2$, whereas the quadrats specified herein are $1.0m^2$ for most measurements.

Thus, the wetland sampling design includes 10 individual fringing wetlands (five from potential dredging impact areas and five from reference areas), to be characterized by sampling conducted along three transects each (as appropriate), with three quadrats sampled (for appropriate parameters) along each transect. The total number of transects sampled will be 30, and the total number of quadrats will be 90. Sampling stations will be allocated among River Sections in a rough proportion to the relative areas of wetland habitat adjacent to dredging locations in each River Section. This design is in keeping with the methods and findings of Findlay et al. (2002) for a generally similar investigation on the Lower Hudson River, with the design modified to fit the site-specific conditions of the Upper Hudson River assessment.

IV. Methods

The following procedures describe the steps for conducting functional assessments of fringing riverine wetlands along the Upper Hudson River. These procedures are modified from, and combine elements of, HGM assessment methods (Ainslie et al., 1999; Findlay et al., 2002) and biological measurement techniques for wetlands (Stevenson and Hauer, 2002; USEPA, 2002a). Data and observations for Items A-E will be obtained from the wetland as a whole. Data and observations for Items F and G will be obtained from transects within each wetland. Data and observations for Items H-N will be obtained from sampling quadrats randomly placed on each transect. Data and observations for Item O will be obtained from the wetland as a whole. DGPS will be used to record positions of transects and quadrats within sample stations of fringing wetlands. If it is determined that no sediment samples are to be collected from within the potentially impacted wetlands by the completion of the SSAP program, sediment samples will be collected from a subset of wetland sampling locations for determination of grain size, TOC, and nutrient content as necessary to adequately characterize the wetlands.

Following the collection of aerial photographs (anticipated to be in July) and digitization, mapping and ground-truthing, fringing wetland habitat will be evaluated during or after peak growing season (July 1 to September 15). The procedures for evaluating the function of fringing wetlands consist of the following steps:

A. Wetland Parcel Size

Measure/Units:
The area of wetland.

Method:
1. Determine the area of the parcel using field reconnaissance, topographic maps, National Wetland Inventory maps (NWI), and/or aerial photography.
2. Report the size of the wetland tract in square meters.

B. Interior Core Area

Measure/Units:
The percent of the wetland parcel with a buffer zone greater than 100 m separating it from non-forested habitat.

Method:
1. Visually determine the area of the wetland tract within a buffer of at least 100 m (i.e., at least 100 m from wetland perimeter) using field reconnaissance, topographic maps, NWI maps, aerial photography, and/or other sources.
2. Report the size of the area within a 100-m buffer as a percentage of total parcel area.

C. Habitat Connections

Measure/Units:
The percent of the perimeter of the wetland parcel that is contiguous with other natural habitats.

Method:
1. Determine the total length of the wetland perimeter using field reconnaissance, topographic maps, and/or aerial photography.
2. Visually determine the length of the wetland perimeter that is contiguous with other natural (vs. maintained or anthropogenic) habitats including other wetlands (fringing and floodplain), wooded or forested riparian tracts, or other vegetated open space.
3. Report as a visual estimate, the percent of the perimeter of the wetland tract that is “connected” (i.e., contiguous to other natural habitats).

D. Soil Integrity

Measure/Units:
The percent of the fringing wetland with soils that appear to have been altered or disturbed by anthropogenic impacts.

Method:
1. Visually determine (from historical aerials and site reconnaissance) if any of the soils in the area being assessed appear to have been altered. In particular, look for alteration to a normal soil profile -- for example, absence of an “A” horizon (defined below), presence of fill material, or

other types of impact that significantly alter soil integrity. Use soil probe or sharpshooter shovel, as appropriate, to obtain sample.

2. Report the percent of the wetland with altered or disturbed soils.

E. Surface Water Connections

Measure/Units:

The percent of the linear length of shoreward bank and riverward edge of the wetland parcel that has been altered to prevent exchange of surface water in or out of wetland.

Method:

1. Conduct a visual reconnaissance of the parcel and the adjacent shoreward bank and riverward edge. Estimate what percent of the length of each that is modified with levees, side cast materials, or other obstructions that reduce the exchange of surface water between the river channel, the wetland, and the floodplain/riparian corridor.
2. Report percent of the linear distance of the bank and riverward edge that has been altered.

F. Elevation

Measure/Units:

The elevation of the shoreward and riverward edges of the wetland parcel.

Method:

1. Randomly select three transect locations along the axis of the wetland parallel to the shoreline. Establish a transect line perpendicular to the long axis at each location.
2. At each transect, locate the shoreward edge of the fringing wetland. Use DGPS to record elevation and position.
3. At each transect, locate the riverward edge of the fringing wetland. Use DGPS to record elevation and position. Report the elevation in feet and inches. Report distance between shoreward and riverward positions.

G. Soil Clay Content

Measure/Units:

The clay content in the top 20 inches (50.8 cm) of the soil profile of the wetland.

Method:

1. Visually determine if the native soil along the transects has been covered with fill material, excavated and replaced, or subjected to any other types of impact that significantly change the clay content of the top 20 inches (50.8 cm) of the soil profile. Use soil probe or sharpshooter shovel, as necessary, to obtain a sample. If no such alterations have occurred, assign a value of 1.
2. If the soils along the transects have been altered in one of the ways described above, estimate the soil texture for each soil horizon in the upper 20 inches (50.8 cm) in representative portions of these areas from field texture determinations done by hand.
3. Based on the soil texture class determined in the previous step, the percentage of clay is determined from the soil texture triangle. The soil texture triangle contains soil texture classes and the corresponding percentages of sand, silt, and clay that comprise each class. Once the soil texture is determined by feel, the corresponding clay percentage is read from the left side of the soil texture triangle. The median value from the range of percent clay is used to calculate the

weighted average. For example, if the soil texture at the surface were a silty clay loam, the range of clay present in that texture class is 28–40%. A median value of 34% would be used for the clay percentage in that particular horizon.

4. Calculate a weighted average of the percent clay in the altered soil by averaging the percent clay from each of the soil horizons to a depth of 20 inches (50.8 cm). For example, if the "A" horizon occurs from a depth of 0–5 inches (0–12.7 cm) and has 30% clay, and the underlying soil from a depth of 6–20 inches (15.2–50.8 cm) has 50% clay, then the weighted average of the percent clay for the top 20 inches (50.8 cm) of the profile is: [(5 × 30) + (15 × 50)] / 20 = 45%.
5. Calculate the difference in percent clay between the natural soil (i.e., what existed prior to the impact obtained from soil survey or reference wetland data) and the altered soil using the following formula: percent difference = (|% clay after alteration - % clay before alteration |) / % clay before alteration). For example, if the percent clay after alteration is 40%, and the percent clay before alteration is 70%, then | 40 - 70 | = 30, and (30 / 70) = 43%.
6. Average the results of the three transects.
7. Multiply the percent difference for the altered area (i.e., the value obtained in the previous step) by the percent of the wetland that the transect area represents (based on visual estimate).
8. Multiply the result by 100 to obtain the percent difference. Report the percent difference in the soil clay content in the area being assessed.
9. On one transect per station, repeat measurements and record separately for reference to measurement variability.

H. Redoximorphic Features and Fluctuating Water Table

Measure/Units:
The presence or absence of redoximorphic features in each sampling quadrat. The presence of a fluctuating water table.

Method:

1. Place 0.25 m^2 quadrats at three locations selected randomly along each transect (quadrats will be placed and sampled sequentially—all need not be placed simultaneously).
2. Visually inspect the top 20 inches (50.8 cm) of the soil profile and determine if redoximorphic features (Verpraskas, 1994), accumulation or organic matter, or other hydric soil indicators are present or absent.
3. Report redoximorphic features as present or absent.
4. To determine the presence of a fluctuating water table, visually inspect the top 20 inches (50.8 cm) of the soil profile for the presence redoximorphic features or a reduced soil matrix (e.g. presence of mottling, low chroma colors, change in chroma hue or color when exposed to air) (USDA, NRCS, 2002).
5. Report fluctuating water table as present or absent.

I. "O" Horizon Cover

Measure/Units:

Percent cover of the "O" horizon (defined as surface layer formed above the mineral layer and composed of fresh or partially decomposed organic material).

Method:

1. Visually estimate the percent of the ground surface that is covered by an "O" horizon (defined above) in each sampling quadrat.

2. Average the results from the quadrats and report “O” horizon cover as a percent.

J. “A” Horizon Cover

Measure/Units:
Percent cover of the “A” horizon (defined as the upper mineral layer composed of organic material mixed with mineral matter, generally the darkest layer in a soil profile).

Method:

1. Estimate the percent of the mineral soil within the top 15 cm (6 inches) of the ground surface that qualifies as an “A” horizon (defined above) by making three soil observations in each sampling quadrat.
2. Average the results from the observations in the quadrat.
3. Report “A” horizon cover as a percent.

K. Plant Species Composition

Measure/Units:
Percent occurrence of dominant species in each relevant vegetative stratum.

Method:

1. Identify the dominant species in the canopy, understory vegetation, emergent layer (the primary and often the only stratum present in the fringing wetlands of the Upper Hudson) and ground vegetation strata using the 50/20 rule (described below). Use tree basal area to determine abundance in the canopy strata, understory vegetation density to determine abundance in the understory strata, emergent vegetation density to determine abundance in the emergent layer, and ground vegetation cover to determine abundance in the ground vegetation strata. To apply the 50/20 rule, rank species from each stratum in descending order of abundance. Identify dominants by summing the normalized abundance measure beginning with the most abundant species in descending order until 50% is exceeded. Additional species with ≥ 20% normalized abundance are also considered dominants.
2. Report percent occurrence of dominant species in all vegetation strata.

L. Invasive Species

Measure/Units:
Percent occurrence of nonnative or invasive species in each relevant vegetative stratum.

Method:

1. Identify any invasive or nonnative species in the canopy, understory vegetation, emergent layer (the primary and often the only stratum present in the fringing wetlands of the Upper Hudson) and ground vegetation strata. Visually estimate the percent of quadrat covered by invasive/nonnative species.
2. Report percent occurrence of invasive/nonnative species in all vegetation strata.
3. For one quadrat per station, repeat measurements and record separately for evaluating measurement variability.

M. Emergent Plant Conformation and Stem Density

Measure/Units:
Stem conformation (length and thickness) and spatial density (stems per unit area) of emergent wetland vegetation.

Method:

1. In each quadrat on each transect, count all stems of dominant emergent macrovegetation. Record density of live and dead stems. In one quadrat per station, repeat count and record separately for reference to measurement variability.
2. From each quadrat, randomly select 10 stems of the dominant species. Measure the maximum total length of each stem to the nearest 0.1 cm. Measure diameter to the nearest 0.01 cm at the thickest part of the stem with calipers. In one quadrat per station, repeat measurements and record separately for reference to measurement variability.
3. Report live and dead stem density per unit area and minimum, maximum and average stem height, thickness, and thickness:height ratio (robustness).

N. Emergent Plant Biomass

Measure/Units:
Biomass per unit area of emergent wetland vegetation

Method:

1. From the same quadrats used in M (above), clip all standing vegetation from within each quadrat after conducting conformation and density measurements. Place in a large plastic bag for return to the processing laboratory.
2. At the processing laboratory, separate live from dead stems. Dry separately to constant weight and record weight. For one quadrat per station, repeat the drying and weighing process and record separately for reference to measurement variability. Drying procedure is as follows:

    a. Clean and dry glass 1 liter (L) beakers to be used for drying the samples.
    b. Determine and record the tare weight of each beaker using precision scale. Mass should be recorded to the nearest 1/100th of a gram.
    c. Use scale to record the initial mass of the sample in the beaker before beginning the drying procedure.
    d. Place the samples in the laboratory oven for 24 hours at 85 (+/- 1) °C. Confirm that the oven is connected to ventilation system through use of flexible ductwork.
    e. Remove samples at the end of 24 hours and place in the desiccator for approximately 45 minutes to confirm the complete removal of water from the samples and to allow for cooling of the sample to room temperature.
    f. Record the mass of the samples immediately after removal from the desiccator.
    g. Return the samples to the oven for 1 hour, place in desiccator and record the mass for constant mass reading (within 5% of the previous measurement).
    h. Repeat Step G until constant mass is reached.
    i. Place samples in sealed bags for archiving and store at room temperature.

O. Wildlife Observations

Measure/Units:
Presence of animal species in wetland habitat being assessed.

Method:

1. When on station, qualified personnel shall survey the wetland being assessed to document the occurrence and signs of wildlife species (e.g., wading birds, small mammals, amphibians, reptiles) using that wetland.
2. Record observations, including a qualitative narrative synopsis, on Table E-1 provided in Attachment E to the HDA Work Plan.

P. Development of FCIs

As discussed in Section I, the specific measurements described above will be used to develop FCIs for each function listed in Table D-1 (above) and each wetland sampled. The FCIs for the wildlife habitat function may include HSIs for representative indicator species. The methods to be used to develop the FCIs will follow the general approach used by Ainslie et al. (1999) and Findlay et al. (2002), with the possible additional use of pre-existing HSI models for the wildlife habitat function. HSI information for selected indicator species will be obtained from http://www.nwrc.usgs.gov/wdb/pub/hsi/hsiindex.htm. Preliminary FCI models and the lists of species for which HSIs will be calculated will be provided in the *Habitat Delineation Report*. The specific methods used will be described, together with the underlying data and the FCI results, in the *Habitat Assessment Reports* referenced in the HDA Work Plan.

V. References

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Table E-1
Fish and Wildlife Survey Form

Date (mm/dd/yyyy): ______/______/______ **Page ___ of ___**

Time: ________________ **Weather Conditions: ______________________________**

Species Name	Number Obs.	Sight Code	Sign Code	Observer's Initials	Habitat Type / Location (approximate)

Instructions:
- Enter species common name in column 1 and number observed in column 2
- Select appropriate "sight" or "sign" codes from below and enter into designated boxes
- Enter initials of Observer
- Enter habitat where species was observed and approximate location in river
- Note exotic species if observed

	Sight Codes:		Sign Codes:		
FG	foraging	**SC**	scat	**CA**	call
FE	feeding	**SL**	slide	**NE**	nest
RS	resting, perching	**DHB**	den, hut, burrow	**TR**	tracks
CA	calling	**TR**	tracks	**FG**	browse
FL	flight	**DB**	day bed	____	other: _________
____	other: _________				

Narrative