Attachment E to Statement of Work

Hudson River PCBs Site

Operation, Maintenance, and Monitoring Scope for Phase 2 of the Remedial Action

December 2010

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1. Background

1.1 Introduction

This Operation, Maintenance, and Monitoring Scope (OM&M Scope) describes the post-construction operation, maintenance, and monitoring (OM&M) program that the General Electric Company (GE) shall carry out under the Remedial Action (RA) Consent Decree. This OM&M Scope sets forth the requirements that GE shall meet in conducting post-construction monitoring and maintenance of the remedy. Specifically, this OM&M Scope covers the following activities:

- Water column, fish, and sediment monitoring following the completion of all remedial activities conducted by GE under the Consent Decree, so as to assess long-term recovery;
- Activities to support evaluation of fish consumption advisories;
- Monitoring and maintenance of sediment caps installed in particular dredge areas in accordance with applicable requirements to implement the Residuals Performance Standard (USEPA 2010a) and EPA-approved design documents, beginning upon installation of such caps; and
- Monitoring and adaptive management of habitat replacement/reconstruction measures implemented in particular river reaches, beginning upon implementation of such measures.

Under Section 4 of the Statement of Work for Remedial Action and Long-Term Monitoring (SOW), which is Appendix B to the Consent Decree, GE will submit to EPA, on an annual basis during Phase 2, an Operation, Maintenance, and Monitoring Plan for Phase 2 Caps and Habitat Replacement/Reconstruction (Phase 2 Cap/Habitat OM&M Plan), or an addendum to a previously approved Phase 2 Cap/Habitat OM&M Plan, which will specify the activities that GE will perform for OM&M of the caps and habitat replacement/reconstruction measures installed in that construction season. That plan or addendum will specify the activities that GE will perform for OM&M of the caps installed in areas dredged in Phase 2 of the RA and will be consistent with Sections 3 and 4 of this OM&M Scope, which specify the requirements for monitoring and maintenance of caps and habitat replacement/reconstruction measures. The Phase 2 Cap/Habitat OM&M Plan and/or addenda will also include any modifications specified, with EPA approval, following Phase 1. GE's performance of OM&M for the Phase 1 caps and Phase 1 habitat replacement/reconstruction measures shall be governed by the September 2005 OM&M Scope and the Operation, Maintenance, and Monitoring Plan for Phase 1 Caps and Habitat Replacement/Reconstruction.

In addition, GE will submit to EPA, within 90 days after completion of installation of all additional habitat replacement/reconstruction measures in the Phase 2 areas in the following construction season, an addendum to the Phase 2 Cap/Habitat OM&M Plan (or any of its updates) which will set forth the requirements for OM&M of those measures.

As provided in Section 3 of the SOW, GE will submit to EPA, by March 15 of the last year of Phase 2, an *Operation, Maintenance, and Monitoring Plan for Water, Fish and Sediment Monitoring* (Water, Fish and Sediment OM&M Plan), which will specify the water column, fish, and sediment monitoring programs that GE will conduct following completion of all remedial activities under the Consent Decree

(excluding OM&M) to assess PCB levels in those media. That plan shall be consistent with Sections 1 and 2 of this OM&M Scope.

1.2 Overall Objectives for OM&M Program

The overall objectives for the OM&M program are as follows:

Overall

- Conduct long-term monitoring in the water column and in fish to provide data on PCB levels over time to assess whether the Remedial Action Objectives (RAOs) and Remediation Goals (RGs) set forth in the ROD are being achieved.

Water Column

- Provide data to assess post-remediation PCB concentrations in surface water and downstream transport of PCBs in the water column over time, and to assess whether the RAOs and the RGs are being achieved.

Fish

- Provide data to assess post-remediation PCB concentrations in fish on a River Section-wide basis, over time and to assess whether the RAOs and the RGs are being achieved.
- Provide data for evaluation of fish consumption advisories.

Sediments

- Provide data on post-remediation PCB levels in sediments in non-dredge areas of the Upper Hudson River.
- Provide data on Select Areas that exceeded the MPA removal criteria that were not targeted for removal because they were buried by cleaner sediments to assess whether the deposits have experienced erosion.
- Provide data on post-remediation PCB levels in backfill to assess how surface concentrations vary over time.

Capping

Confirm that the physical integrity and chemical isolation effectiveness of the caps placed in areas that did not achieve the applicable numerical residuals standard (including, as required, both caps designed to physically isolate such residuals and caps designed to physically and chemically isolate remaining inventory) is maintained; and if not, perform appropriate maintenance.

Habitat

- Evaluate whether, and the extent to which, the replacement/reconstruction of habitat in a given extent of the river is achieving the goal of replacing the habitat functions, as measured by certain specified parameters (listed in Section 4.2.3 below), to within the range of functions found in similar physical settings in the Upper Hudson River, given changes in river hydrology, bathymetry, and geomorphology resulting from the remedy and other factors; and if not, take appropriate adaptive management measures.

2. Monitoring Short and Long-Term Recovery

This section describes the short-term and long-term water column, fish, and sediment monitoring programs that GE shall conduct under the Consent Decree to assess long-term recovery of PCB levels. The requirements of this section shall apply only if GE notifies EPA that it will implement Phase 2 pursuant to the Consent Decree. These programs shall commence upon completion of all remedial activities conducted by GE under the Consent Decree. Prior to that time, the monitoring of the water column, sediment, and fish shall be conducted as part of the Remedial Action Monitoring Program (RAMP), as described in the Phase 2 RA Monitoring Scope (USEPA 2010b).

2.1 Water Column Monitoring

2.1.1 Data Quality Objectives

The objectives of the water column monitoring are to:

- provide water column PCB concentration data over time to assess whether the RAOs and the following RGs are being achieved:
    - (0.5 µg/L [500 ng/L] (federal MCL);
    - 0.09 µg/L [90 ng/L] (NYS standard for protection of human health and drinking water sources);
    - 0.03 µg/L [30 ng/L] criteria continuous concentration (CCC) Federal Water Quality Criterion (FWQC) for saltwater;
    - 0.014 µg/L [14 ng/L] CCC FWQC for freshwater);
- determine whether the remedy has been effective in minimizing long-term downstream transport of PCB load; and
- determine the level of PCB concentrations entering the river from upstream of the project area and from the Mohawk River.

To achieve these objectives, GE shall implement the water column monitoring program described below. Sections 2.1.2 through 2.1.5 describe the initial scope of that program, which shall continue for a minimum of three years after the completion of all remediation that is carried out under the Consent Decree. Section 2.1.6 specifies procedures and criteria for modifying the program at the end of that three-year period and/or at any time thereafter, as well as procedures and criteria for termination of the program.

2.1.2 **Sampling Locations**

In general, sampling locations were identified to coincide with the Baseline Monitoring Program (BMP) locations and at a scale at which the remedy effectiveness was evaluated in the Feasibility Study (FS; USEPA 2000) and the ROD.

The primary water column monitoring location shall be at Waterford (at approximate River Mile [RM] 156.0). This station will monitor transport of PCB mass to the Lower Hudson River and PCB concentrations attained at the end of the Upper Hudson River. Flow rates also will be measured at this station. Secondary monitoring locations shall be established at Thompson Island (~ RM 187.5) and Schuylerville (~ RM 181.4). These stations will monitor transport of PCB mass and PCB concentrations attained at the end of River Section 1 and River Section 2 (as defined in the ROD), respectively. In addition, flow rates shall be monitored at Schuylerville to calculate summer PCB load (PCB loads are highest in summer based on historical data). Measurements of flow can be obtained at Schuylerville using the existing gauge or by installation of an automated station. The calibration of the existing gauge should be confirmed prior to use.

Additional monitoring stations shall be established at Rogers Island (~ RM 194.2) and Bakers Falls (~ RM 196.9). Monitoring at these locations shall also satisfy the requirements of the consent decree for the Post-Construction Monitoring Program of the Remnant Deposits (*United States v. General Electric Company*, No. 90-CV-575, April 6, 1990) and to assess PCB concentrations from upstream source areas, including the Remnant Deposits.

If GE notifies EPA that it has elected not to perform Phase 2 of the RA pursuant to the Consent Decree, GE shall continue to monitor the water column to satisfy the requirements of the consent decree for the Post-Construction Monitoring Program of the Remnant Deposits.

The Stillwater station (~ RM 168.4) shall be monitored for diagnostic purposes if the other monitoring stations indicate that PCB concentrations in the river are not declining as expected. Two additional stations shall be located in the Lower Hudson River at Albany (RM 140) and Poughkeepsie (RM 77) to provide an indication of PCB concentration trends in the non-saline portion of the Lower Hudson River. A third station at the Mohawk River at Cohoes shall be monitored to assess PCB concentrations from other sources. The specific locations of these monitoring stations shall be as close as practical to the comparable BMP stations, although some modifications to those locations may be made based on conditions at the time, with EPA approval, or if GE decides to collect the water column samples using the automated stations installed for the remedial action.

2.1.3 **Sampling Frequency and Duration**

Sampling frequency is based on the seasonal variability in PCB concentrations and the downstream transport of PCBs during high flow events.

Sampling shall occur weekly at Waterford throughout the year, with additional rounds of sampling during high flow events meeting the definition of high flow events in the revised RAMP QAPP or RAMP QAPP addendum. Sampling at Thompson Island shall occur weekly from March to November. Sampling at Schuylerville shall occur weekly from March to November and every two weeks from December to February. Sampling for high flow events shall also be considered for Thompson Island and Schuylerville,

subject to approval by EPA. Sampling at Rogers Island shall occur weekly from March to April, and every two weeks from May to February. Sampling at Bakers Falls shall occur monthly from April to November. The sampling frequency for Rogers Island and Bakers Falls may need to be revised (*i.e.*, increased) if PCB concentrations observed at those stations during the RA or OM&M period are significantly higher than the current levels. The two Lower Hudson River stations shall be sampled monthly from May to November. If the PCB concentrations at Albany are shown to exceed those at Waterford, GE shall collect a grab sample at the Mohawk River at Cohoes to investigate whether the Mohawk is the source of elevated PCB levels in the Lower Hudson River. If sampling indicates that PCB levels in the Mohawk River have increased significantly, the Mohawk River station shall be sampled at the same frequency as the Albany and Poughkeepsie stations during the period of elevated PCB concentrations at Albany and maintained at that level until the conditions for reverting to routine monitoring are met.

2.1.4 **Measurements**

The routine measurements on water samples will include PCBs and total suspended solids (TSS). Suspended solids analysis shall be conducted using USEPA Method 160.2, with modifications to be consistent with American Society for Testing and Materials (ASTM) Method D 3977-97. Analysis of whole water PCBs shall be conducted using the modified Green Bay Method (mGBM) and extraction protocols subject to revisions approved by EPA. Due to concerns raised by EPA on the analytical results generated by using mGBM during Phase 1, the correction factor used to modify the Peak 5 mass for BZ4 plus BZ10 is being eliminated from the mGBM (please see EPA letter to GE dated October 12, 2010). As a result, a portion of these samples shall be analyzed for PCBs via USEPA Method 1668b at the same frequency required during the construction period, unless data obtained during the construction period shows it can be reduced or eliminated. A minimum of 5 percent of samples will be analyzed by USEPA Method 1668b. During the course of long-term monitoring, specific analytical protocols and sampling procedures may be updated by GE based on the latest available technologies and implemented upon EPA approval.

Surface water samples shall also be measured for temperature, specific-conductivity, pH, turbidity, and dissolved oxygen (DO) using a probe at each sampling station. Associated measurements shall be made for river flow at both Waterford and Schuylerville.

In addition, the OM&M monitoring program may, upon agreement between EPA (after consultation with the New York State Department of Environmental Conservation [NYSDEC]) and GE, be modified to include monitoring for metals on a monthly basis during the first year of the OM&M program at stations to be agreed upon by EPA and GE. In the absence of agreement between GE and EPA, the frequency of metals analysis and stations shall be determined by EPA. If such monitoring is conducted, it will be evaluated at the end of the first year of the OM&M program and may, upon agreement of the parties, be discontinued thereafter.

2.1.5 **Sampling Protocol**

Sampling shall consist of single-day upstream to downstream sampling. A single composite sample shall be generated for each station. At the Upper Hudson River stations, samples shall be collected using the equal discharge increment (EDI) protocol, similar to that used in the BMP. Sampling shall occur at 6

equal-flow locations over the cross section at the Thompson Island and Schuylerville stations, and 5 locations at the other stations. If the location of a station is changed so the station is not located at or near an island, only 5 EDI locations per station will be needed. The entire sample volume from each location along the transect shall be combined to generate a single composite sample for each of these monitoring stations. As an alternative to manual sampling, automated samplers as used during the RAMP may be used at these stations for this long-term monitoring program.

At the two Lower Hudson River stations and at the Mohawk River station, sampling shall be conducted using the manual BMP sampling protocol, which consists of vertically integrated sampling at a centroid location at each station.

2.1.6 **Modifications to Program and Program Termination**

Sampling shall be conducted at the stations and frequencies specified above, using the above-described protocols, for a three-year period after the completion of all remediation under the Consent Decree. At the end of that three-year period, GE shall review the data collected under this program and evaluate whether reductions or modifications to the program could cost-effectively achieve the data quality objectives set forth in Section 2.1.1. It is the parties' expectation that the scope of the program may be reduced at the end of that three-year period. At that time, GE may submit a written proposal to reduce the number of sampling stations and/or the sampling frequencies, or to make other modifications to the sampling program, for a subsequent period. Any such proposal will be reviewed by EPA to determine whether the above data quality objectives can be achieved with such a reduction in stations or frequencies or other modifications. EPA will notify GE of its determination; GE shall continue to implement the water column monitoring program with any such modifications that EPA has approved.

At any time following this three-year review, if GE concludes that further reductions or other modifications to the monitoring program are warranted and can achieve the above data quality objectives, GE may submit a written proposal for such further reductions or modifications; and it shall implement such changes upon EPA approval. At the end of 20 years of monitoring or at any time thereafter, if GE concludes that further reductions or other modifications to the monitoring program are warranted and can achieve the above data quality objectives or that monitoring is no longer necessary to achieve those objectives, GE may submit a written proposal for such further modifications or a termination of the program, as appropriate. GE shall implement such changes or termination upon EPA approval. Otherwise, monitoring shall continue until EPA determines that the relevant RAOs and RGs set out in the ROD have been achieved.

2.2 Fish Monitoring

2.2.1 **Data Quality Objectives**

The objectives of the fish monitoring are to:

- provide data on PCB concentrations in fish over time to assess whether the RAOs, RGs and target levels set forth in the ROD for reducing the cancer risks and non-cancer health hazards for people eating fish from the Hudson River (0.05 mg/kg PCBs in fish fillet; 0.2 mg/kg PCBs in fish fillet; and 0.4 mg/kg PCBs in fish fillet) and the risks to ecological receptors (from 0.3 to 0.03 mg/kg

PCBs fish [largemouth bass, whole body]; and 0.7 to 0.07 mg/kg PCBs in spottail shiner [whole fish]) are being achieved; and

- provide data on PCB concentrations in Hudson River fish to the New York State Department of Health (NYSDOH) for evaluation of fish consumption advisories.

To achieve these objectives, GE shall implement the fish monitoring program described in Sections 2.2.2 through 2.2.8. Sections 2.2.2 through 2.2.6 describe the initial scope of that program, which shall continue for a minimum of three years after the completion of all remediation under the Consent Decree. Section 2.2.7 specifies procedures and criteria for modifying the program at the end of that three-year period and/or at any time thereafter, as well procedures and criteria for termination of the program. In addition, Section 2.2.8 describes a supplemental fish monitoring program that GE shall conduct for the specific purpose of providing PCB data to NYSDOH to evaluate whether existing fish consumption advisories should be modified.

2.2.2 **Sampling Locations**

This section describes the fish sampling locations that will be monitored during the first three years of the program to document the response of the river to remediation. These locations will continue to be monitored unless the program is modified as described in Section 2.2.7.

In the Upper Hudson River, fish sampling shall be conducted at locations identified to coincide with the BMP and RAMP fish sampling locations and to evaluate spatial trends in PCB concentrations observed from sampling during baseline and RA conditions. Specifically, fish sampling shall be conducted in the Upper Hudson River from each of the river sections at the stations listed below:

- Feeder Dam (representative of reference conditions);
- Thompson Island Pool (representative of River Section 1);
- Northumberland/Fort Miller Pools (representative of River Section 2); and
- Stillwater Pool (representative of River Section 3).

In the Lower Hudson River, fish monitoring shall be conducted at the following stations:

- Albany/Troy (location shall coincide with the BMP and the RAMP fish sampling locations);
- Catskill; and
- Tappan Zee area.

2.2.2.1 **Upper Hudson River**

Sampling shall occur initially in areas of Feeder Dam, Thompson Island, Northumberland/Fort Miller, and Stillwater pools that provide a representation of the River Section-wide average levels in the targeted species. Data obtained during baseline and RA monitoring shall be used to establish the sampling locations. During the sampling period, the sampling will occur at the BMP and RAMP sampling locations

to the extent practical. Sampling locations shall be adjusted, as necessary, in consultation with EPA, to reflect changes that occur as habitat replacement/reconstruction progresses. The guiding principle shall be to use a sufficient number of sampling locations to produce representative samples to determine River Section-wide average PCB concentrations in fish.

2.2.2.2 **Lower Hudson River**

One location each shall be sampled at Albany/Troy, Catskill, and the Tappan Zee area to monitor PCB levels in Lower Hudson River fish. The species to be sampled at these stations are listed in Section 2.2.4.2 below.

2.2.3 **Sampling Frequency**

During the first three years of the fish monitoring program (and unless the program is modified following the initial three-year period as described in Section 2.2.7), sampling shall be conducted annually at the Upper Hudson River stations. At the Lower Hudson River stations, fish sampling during this period shall be conducted annually at Albany/Troy and once every two years at Catskill and Tappan Zee.

2.2.4 **Species and Sampling Methods**

This section specifies the species to be sampled for the first three years of the fish monitoring program (unless the program is modified following the initial three-year period as described in Section 2.2.7).

2.2.4.1 **Upper Hudson River**

In the Upper Hudson River, the same species groups as are sampled in the BMP shall be collected. These species groups are:

- black bass (largemouth and/or smallmouth bass, with a goal of half of each species but in whatever combination is available to meet the applicable sample size specified in Section 2.2.5);
- ictalurids [bullhead (brown and/or yellow) and/or channel catfish (white and/or channel)], with a goal of half of each species but in whatever combination is available to meet the applicable sample size specified in Section 2.2.5);
- yellow perch;
- yearling pumpkinseed; and
- forage fish (spottail shiner and/or alternative).

Standard sampling methods, including netting, electroshocking, and angling, shall be used to collect target species. The samples to be processed for analysis shall be standard fillets for bass, bullhead, catfish, and perch; individual whole body samples for yearling pumpkinseed; and whole body composites for spottail shiners or other forage fish species.

2.2.4.2 **Lower Hudson River**

At the Lower Hudson River stations, the following species groups shall be sampled as part of the fish monitoring program (with additional species to be collected as part of the supplemental sampling program described in Section 2.2.8):

- At Albany/Troy the same species groups as are sampled in the BMP shall be collected, with the addition of striped bass. Specifically, striped bass, black bass (largemouth and/or smallmouth bass, 10 of each, or in whatever combination is available for a total of 20), ictalurids [10 bullhead (brown and/or yellow) and/or 10 catfish (white and/or channel), or in whatever combination is available for a total of 20], and perch (white and/or yellow, 10 of each, or in whatever combination is available) shall be collected annually; yearling pumpkinseed and forage fish (spottail shiner and/or alternative) shall be collected annually for the first three years and once every two years thereafter, in the same years as the biennial striped bass sampling.

- At Catskill, striped bass, black bass (largemouth and/or smallmouth bass, 10 of each, or in whatever combination is available), and ictalurids [10 bullhead (brown and/or yellow) and/or 10 catfish (white and/or channel), or in whatever combination is available] shall be collected annually.

- At Tappan Zee area, striped bass shall be collected annually.

Standard sampling methods, including netting, electroshocking, and angling, will be used to collect target species. These samples shall be processed as standard fillets for bass, bullhead, catfish, and perch; individual whole body samples for yearling pumpkinseed; and whole body composites for spottail shiners or other forage fish species.

2.2.5 **Sample Size**

Sample size within each pool in the Upper Hudson River shall be the same as described in the BMP QAPP (QEA 2004). For locations where individual fish will be submitted for analysis, the number of fish to be collected shall consist of a maximum of: 20 individuals per species group at Feeder Dam; 25 individuals per species group at Northumberland/Fort Miller pool; and 30 individuals per species group at each of the Thompson Island and Stillwater pools; provided that more of one species in a group may be collected than another in order to achieve the total if one species is present in smaller numbers or not at all. The individuals may be collected from multiple stations within the pool, as necessary to achieve a representative River Section-wide average. In addition, where forage fish will be sampled, ten whole body composites of forage fish shall be collected from each pool (two composites per location).

At each of the Lower Hudson River stations, a maximum of 20 individuals of each target species or species group shall be collected.

2.2.6 **Measurements**

PCBs and percent lipid shall be measured to monitor PCB levels in fish. All fish samples shall be analyzed for total PCBs using a modification of the USEPA Method 8082 Aroclor Sum Method, as specified in the BMP QAPP (QEA 2004), unless EPA determines that the data quality objectives set forth

in Section 2.2.1 can no longer be assessed by that method. Analysis by the mGBM will be performed on 5 percent of the total number of samples during every other sampling event that is conducted at a given sampling location, in order to verify that the Aroclor method is accurately quantifying the Total PCB concentrations in fish, as the congener pattern in fish may change as a result of the remediation, which may affect the quantification by the Aroclor method. A performance evaluation sample for fish tissue in the form of the Hudson River Reference Material (HRM) developed by NYSDEC shall be incorporated into the program. The weight and length of collected fish also shall be measured at the time of collection to assess fish condition. Captured fish shall be visually inspected for external abnormalities (*e.g.*, tumors, lesions). Sex of fish will be determined, if possible, prior to processing in the analytical laboratory. Scale samples will be collected from pumpkinseeds to estimate age on an annual basis to ensure that they are yearling fish (age 1+).

2.2.7 **Modifications to Program and Program Termination**

The fish sampling program described in the preceding subsections shall be conducted for a three-year period after the completion of all remedial activities conducted by GE under the Consent Decree. At the end of that period, GE shall review the data collected under this program and evaluate whether reductions or other modifications to the program for either the Upper or Lower Hudson River (or both) could cost-effectively achieve the data quality objectives set forth in Section 2.2.1. It is the parties' expectation that the scope of the program may be reduced at the end of this three-year period. At that time, GE may submit a written proposal to reduce the number of sampling locations, the species sampled, and/or the sampling frequencies, or to make other modifications to the sampling program, for a subsequent period. Any such proposal will be reviewed by EPA in consultation with NYSDEC and NYSDOH to determine whether the above data quality objectives can be achieved with such reductions or other modifications. EPA will notify GE of its determination; GE shall continue to implement the fish sampling program, with any such modifications that EPA has approved.

At any time following this three-year review, if GE concludes that further reductions or other modifications to the above monitoring program are warranted and can achieve the above data quality objectives, GE may submit a written proposal for such further reductions or other modifications; and it will implement such changes that are approved by EPA, upon consultation with NYDEC and NYSDOH. At the end of 20 years of monitoring or at any time thereafter, if GE concludes that further reductions or other modifications to the monitoring program are warranted and can achieve the above data quality objectives or that monitoring is no longer necessary to achieve those objectives, GE may submit a written proposal for such further reductions or modifications or a termination of the program, as appropriate. GE will implement such changes or termination approved by EPA after consultation with NYSDEC and NYSDOH. Otherwise, fish monitoring shall continue until EPA determines that the relevant RAOs and RGs set out in the ROD have been achieved.

2.2.8 **Supplemental Fish Sampling Program for Fish Consumption Advisory Assessment**

In addition to the fish monitoring program described above, GE shall conduct a supplemental fish sampling program to provide PCB data to the NYSDOH for use in evaluating whether existing fish consumption advisories should be modified. This supplemental program shall involve collection of the following samples (in addition to those described in prior sections):

- At Albany/Troy, collection of 10 individual samples each of walleye, carp, and herring (alewife and/or blueback);

- At Catskill, collection of 10 individual samples each of white perch, walleye, carp, catfish (white and/or channel) (not required if collected as a part of fish monitoring under Sections 2.2.4 - 2.2.6) and herring (alewife and/or blueback);

- At Poughkeepsie, collection of 20 individual samples of striped bass and 10 individual samples each of white perch, carp, catfish (white and/or channel), American eel, black bass (largemouth and/or smallmouth), and herring (alewife and/or blueback); and

- In the Tappan Zee area, collection of 10 individual samples each of white perch, catfish (white and/or channel), carp, American eel, and bluefish.

This supplemental sampling shall be conducted on three occasions – once in the first, second, and third years of the fish OM&M program. The samples shall be processed for analysis as standard fillets, and shall be analyzed for PCBs (using the same method described in Section 2.2.6) and percent lipids.

At any time after completion of the three supplemental sampling rounds described above, if the NYSDOH notifies GE and EPA that (a) it (NYSDOH) has determined that additional sampling is necessary in order to evaluate whether to modify its fish consumption advisories for PCBs at one or more locations in the Upper or Lower Hudson River, (b) additional fish data on levels of PCBs that are present in or may have migrated from the Upper Hudson River are necessary for that evaluation, and (c) it proposes that GE collect such additional data for particular species and locations, then GE shall conduct additional supplemental fish sampling of those species, and at those locations, that are agreed upon by GE and EPA or, in the absence of such an agreement, that are determined by EPA after consultation with NYSDOH and NYSDEC. The geographic scope of this additional supplemental fish sampling program shall be from the Tappan Zee area north to Bakers Falls, as appropriate. Additional sampling and analysis, if necessary, will only be required where the primary source of PCBs is reasonably expected to be from the Upper Hudson River. (For the purpose of this agreement, the sampling stations identified in this plan for years 1 through 3 meet this criterion.) In the event that the parties do not agree on such supplemental sampling, EPA will provide GE with the rationale for its determination that additional sampling is warranted to provide the data necessary to enable NYSDOH to evaluate whether fish consumption advisories applicable to the foregoing geographic area may warrant a change.

2.3 Sediment Monitoring Program

2.3.1 **Data Quality Objectives**

The objectives of the sediment monitoring are to:

- Determine post-remediation PCB levels in sediments in non-dredge areas of the Upper Hudson River.

- Provide data on Select Areas that exceeded the MPA removal criteria that were not targeted for removal because they were buried by cleaner sediments to assess whether the deposits have experienced erosion.

- Determine sediment recovery rates in non-dredge areas of the Upper Hudson River.
- Examine the changes to surface PCB concentrations in backfill areas.

2.3.2 Non-Dredge Area and Backfill Sediment Sampling

2.3.2.1 Sampling Locations and Frequency

The Peer Review Panel recommended evaluation of sediment recovery rates in the Upper Hudson River, including both non-dredge areas as well as areas that will be backfilled in accordance with the Phase 2 Residuals Engineering Performance Standard. The non-dredge area sampling program shall examine the same areas sampled as part of the surface sediment sampling program initiated by EPA in 2010. Approximately 350 sampling locations shall be sampled by GE in each sampling event. To the extent that some of the locations will be subsequently dredged after the 2010 sampling event, other non-dredge surface sample locations may be substituted, at EPA's discretion. These surface sediments will be sampled upon completion of dredging in each river section and then every 3 years after that time until satisfying the recovery criteria identified in the approved Adaptive Management Plan. As described in the Phase 2 RAM Scope (Attachment B to the Consent Decree SOW), this program which shall be started during the construction period and is anticipated to be continued post-construction. Depending on the results of the construction monitoring, this non-dredge area sediment sampling program may be reduced or eliminated, at EPA's discretion. These samples will track the recovery of surface sediments in non-dredge areas.

The backfill sampling program will entail collection of samples from a minimum of 50 locations from backfilled areas in each river section. These locations will be sampled at the same frequency as the non-dredged areas.

2.3.2.2 Sampling Methods

The samples shall be collected from the non-dredge and backfill areas by coring, vibracoring, or manual coring techniques. In both the non-dredge and backfill areas, each core shall be segmented into 0- to 2-inch and 2 to 12-inch segments. Only the 0 to 2-inch segment will be analyzed. The 2 to 12-inch segment will be examined to evaluate the texture of the freshly deposited material and the underlying sediments. The core segments will be individually analyzed to track changes in the sediments over time, yielding approximately 500 samples per sampling event.

2.3.2.3 Measurements

GE shall analyze sediment samples for Aroclor-based PCBs using Method GEHR8082, the same method used during the SSAP (ESI and QEA 2002). The PCB Aroclor data shall be converted from Total PCBs to Tri+ PCBs using the regression model developed and refined during the construction period, consistent with the procedures specified in the Phase 1 and Phase 2 RAM QAPPs. That is, the regression shall be established using paired data analyzed by Method GEHR8082 and the mGBM. A portion of the sediment samples shall be analyzed by the mGBM at a rate of 4 percent in order to confirm the accuracy of the Tri+ PCB equation. GE shall also analyze all sediment samples for Total Organic Carbon (TOC) using the method specified in the SSAP QAPP (ESI and QEA 2002). A subset of the 0 to 2-inch layer will also be analyzed for the radioisotope Beryllium-7 (Be-7) to identify recent deposition. The number and sampling

locations for Be-7 analysis will be based on the results of the 2010 surface sediment sampling program initiated by EPA, but are expected to represent about 30 locations per river section.

Recently-deposited sediments are a distinct subset of the surface sediments that represent the chemical characteristics of suspended sediments as they settle out of the water column at the time of their collection and they can be distinguished from other surface sediments by the presence of Be-7. Be-7 is a naturally occurring radionuclide with a half-life of 53 days and is detectable in sediments within approximately 4 half-lives, or about 200 days. The hydrophobic nature of Be-7which strongly partitions to the sediment, makes this radionuclide a useful tracer of short-term sediment dynamics. With a high K_d, Be-7 remains sorbed to particles in the water column and does not readily partition to the dissolved phase. The presence of Be-7 in sediment can therefore be used to track sedimentation and resuspension regimes in high-energy systems like the Upper Hudson River, where turbulent water scours the sediment surface and erosion and deposition mechanisms significantly impact the movement of contaminants like PCBs. Therefore, the presence or absence of Be-7 in backfilled and non-dredge areas will help to evaluate the recovery in the Upper Hudson River.

2.3.3 **Bathymetric Survey of Select Areas**

2.3.3.1 **Locations and Frequency**

In the first and ninth years following completion of the Phase 2 dredging program, GE shall conduct bathymetric surveys of Select Areas that exceeded the MPA removal criteria but were not targeted for removal because they were buried by cleaner sediments. These areas shall be identified in the *Final Phase 2 Dredge Area Delineation Report*.

2.3.3.2 **Methodology**

Bathymetry surveys will be conducted in conformance with National Oceanographic Service (NOS) Hydrographic Surveys Specifications and Deliverables (NOS, 2003) and U.S. Army Corps of Engineers (USACE) standards for navigational dredging and, where applicable, modified procedures will be used to provide as detailed a riverbed elevation map as possible in near-shore, shallow areas. Depending on the nature of the Select Areas (*e.g.*, water depth, density of aquatic vegetation, obstructions), multibeam and/or single-beam technology may be used to conduct these surveys. Multibeam survey techniques, if applicable, will be consistent with those performed under Addendum 1, Supplemental Engineering Data Collection Work Plan (BBL, 2005). Single-beam techniques will be consistent with SSAP QAPP (ESI and QEA, 2002), with the exception that the space between survey lines may be reduced to sufficiently capture bottom elevation variability for the purposes of meeting survey DQOs (*e.g.*, lines every 25’ to 50’).

2.4 Reporting

GE shall provide the data from the water column, sediment, and fish monitoring programs to EPA in the monthly reports and monthly database updates under the Consent Decree. GE shall also provide the data upon receipt from the laboratory if requested by EPA. In addition, GE shall provide annual Data Summary Reports (DSRs) that document the data collected in each calendar year in both the water column and fish monitoring programs. These reports shall be submitted by March 15 of the following

year. Each DSR shall fully document the prior calendar year's work, including a summary of the work performed, a tabulation of results, field notes, processing data, chain-of-custody (COC) forms, copies of laboratory audits, data validation results, copies of laboratory reports, and a compact disk version of the project database.

3. Cap Monitoring and Maintenance

3.1 Program Objectives

3.1.1 Backfill

Under the Residuals Performance Standard (Revised Engineering Performance Standards For Phase 2 Dredging, USEPA 2010a), backfill, as opposed to an engineered cap, shall be placed in a dredge area when the appropriate numerical residuals standard (average surface Tri+ PCB concentration in the 1-acre subunit or 5-acre CU is less than or equal to 1 mg/kg), as set forth by USEPA (2010a), has been met, subject to the requirements of the EPA-approved Phase 2 Final Design, which may identify certain areas where backfill will not be installed (*e.g.*, navigation channel) when the requirements of the Residuals Performance Standard have been met. Since, in such cases, the numerical residuals standard has been achieved, monitoring of backfill shall consist of verifying that backfill has been installed in accordance with the design specifications (*i.e.*, use of materials with acceptable physical and chemical characteristics placed to the design elevations). Such backfill monitoring shall be specified in the Phase 2 Final Design documents and Phase 2 Construction Quality Assurance Plan (Phase 2 CQAP) and will not be part of the OM&M program. No long-term monitoring of the backfill for containment purposes shall be required. However, the habitat monitoring and maintenance activities shall include monitoring of backfill as necessary and appropriate for purposes of the habitat replacement/reconstruction program, as discussed further in Section 4.

3.1.2 Engineered Caps

GE shall conduct monitoring and maintenance shall be conducted for engineered caps. The monitoring and maintenance objectives consist of the following:

- determine whether the physical integrity of individual cap layers/components has been maintained through the use of sediment cores and other means;
- determine whether the chemical isolation effectiveness of the cap component for chemical isolation has been maintained;
- determine whether there is a need for additional protective measures and institutional controls (*e.g.*, additional controls for caps in the navigational channel, notifications to boaters regarding actions in capped areas, *etc*.); and
- determine whether the physical integrity and chemical isolation effectiveness of cap layers/components installed in known fish spawning areas (*e.g.*, West Griffin Island Area) are maintained through monitoring with response thresholds at a spatial scale appropriate for the extent and depth of cap placed within the spawning ground and the nature of the potential disturbance (*e.g.*, an area less than 4,000 sf or an area less than 20% of the cap).

Several types of engineered caps are being designed for use in Phase 2. Definitions for these types of engineered caps are provided in the Critical Phase 2 Design Elements.

The OM&M program for engineered caps shall commence with EPA approval of the cap installation in a given CU and shall continue in perpetuity. In practice, this program shall be implemented by GE on an annual basis – *i.e.*, the caps which are installed in a given season will be monitored and maintained as a group.

3.2 OM&M Program

As part of construction, upon satisfactory completion of cap installation (as specified in the Phase 2 CQAP), record drawings (plans and cross-sections) will be developed. These drawings will verify that the engineering specifications for the cap (as specified in the Phase 2 *Final Design Report*) have been achieved in the field. This verification will include a bathymetric survey to document cap elevations after placement. Following construction, GE shall implement a tiered monitoring program for each cap type, using a similar framework (described below) to that recommended by the U.S. Army Corps of Engineers - Waterways Experiment Station in *Guidance for Subaqueous Dredged Material Capping* (USACE-WES 1998), and by USEPA in *Guidance for In-Situ Subaqueous Capping of Contaminated Sediments* (USEPA 1998). This framework is set out below.

The first tier of monitoring shall be to determine whether the caps remain in place over time. Bathymetric surveys shall be used as the primary means to evaluate the integrity of the cap. A bathymetric survey shall be performed one year following placement of the cap. This bathymetric survey shall be referred to as the "Year 1 Survey" and shall be performed for all areas that are capped during the prior dredging season, regardless of size of the capped area. The Year 1 Survey may be used as the baseline for subsequent cap measurements to account for any consolidation and associated settlement, the majority of which would be expected to take place within the first year following placement of the cap. If the Year 1 Survey does not indicate that any settlement has occurred since the cap was installed, the record drawings of the cap shall be used as the baseline for subsequent cap measurement. However, if the Year 1 Survey shows areas of suspected cap loss, compared to the record drawings of the cap, such data shall be confirmed through visual investigation (underwater camera, diver, side-scan sonar where appropriate, *etc.*). If it is confirmed that those areas have lost more than three inches of thickness over 4,000 square feet (sf), or 20% of the cap area, whichever is less, of a contiguously capped area, the cap shall be repaired by GE as necessary.

Subsequent bathymetric surveys shall be performed five and ten years after construction of the cap and continued thereafter at 10-year intervals in perpetuity. In addition, if a flood event with a magnitude at or exceeding the design recurrence interval for the cap (*i.e.*, a 100-year recurrence interval for engineered cap) occurs, the cap shall be inspected through a bathymetric survey and collection of sediment cores as soon as practical after the event. If such an event occurs in the same year in which routine periodic monitoring of the cap is scheduled, the event-based monitoring shall replace the routine monitoring survey for that year. Following the completion of dredging, the routine 10-year interval monitoring events shall be consolidated so that they are performed in perpetuity for all cap areas at intervals of 10 years after installation of the last cap installed by GE as part of the RA.

Based on the results of each of the surveys, including those conducted at 10-year intervals in perpetuity as set forth above, sediment elevations from the current monitoring event shall be compared to those shown on the record drawings and/or the Year 1 Survey, as appropriate, and to the prior monitoring event using an "elevation difference" plot. The goal will be to determine whether there is a measurable loss in cap

material elevation since the cap was installed and between monitoring events. This shall be defined as a measurable loss of greater than three inches in cap thickness over a contiguous 4,000 sf area or 20% of the cap area, whichever is less, considering both the accuracy of the measurement technique and the nature of the cap surface (*e.g.*, irregular rock surface). If a measurable loss in elevation is observed, a second tier of monitoring shall be conducted, including visual investigation (underwater camera, diver, side-scan sonar where appropriate, *etc*.) of the cap area, followed by confirmatory physical investigations to ascertain whether there is a significant loss of cap material (defined as greater than three inches in thickness over a contiguous 4,000 sf area or 20% of the cap area, whichever is less).

If the investigation confirms that there is significant cap loss, those sections of the cap shall be repaired as needed. This obligation to make needed repairs shall continue in perpetuity, in conjunction with the perpetual obligation to conduct surveys as set forth above. A survey shall follow the cap repair to confirm that the repair was performed satisfactorily and shall be used as the new "baseline" survey. Following cap repair, results from the monitoring event survey shall be compared to the post-cap repair survey, and the same cap loss metrics identified above shall be used to assess cap integrity. If a cap is placed over a contiguous area that is less than a half-acre in size, it shall be considered individually for the above evaluation purposes. If a significant cap loss of a particular cap type is identified during any monitoring event, all caps of the same type (or lesser) that were installed in similar physical settings but not monitored in that event will be reviewed to determine if there is more widespread damage.

3.2.1 **Elevation Surveys/Hydrographic Surveys**

Multi-beam hydrographic surveys shall be the preferred method of survey. Such surveys shall be conducted using USACE Hydrographic Survey standards (USACE 2002). Transect spacing will be varied with water depth to allow for sufficient coverage of the capped area being surveyed (estimated coverage is approximately 3.4 times water depth for each boat pass). In many instances, multi-beam surveys can produce vertical accuracy of approximately three inches, although performance at any given site under unknown conditions cannot be guaranteed. In near-shore areas, or areas where water depths do not allow for multi-beam hydrographic surveys, topographic survey shall be employed. Both survey methods were utilized by GE during the 2009 Phase 1 dredging, but GE did not explain how the two data sets and the associated errors were combined. For Phase 2, GE will be required to demonstrate how multi-beam hydrographic survey and topographic survey data are combined with analyses of the error associated with each data set.

3.2.2 **Visual Investigations**

If a measurable loss in cap elevation is observed based on comparison of the current bathymetric survey to the elevation of the cap as shown on the record drawings and/or the Year 1 Survey, as appropriate, and elevations previously measured, then visual investigations shall be conducted by underwater camera, diver(s), or other techniques to confirm the condition of the cap. A visual notation of the thickness and physical description of the materials shall be used to determine the thickness of the cap, including isolation layer and armor (if any). If the investigation shows significant loss of the cap armor material (*i.e.*, > 3 inches in thickness over a contiguous 4,000 sf area, 20% of the cap area, whichever is less), cores of the cap isolation layer shall be retrieved for visual evaluation of any potential loss in isolation layer thickness.

3.2.3 **Chemical Isolation Layer Effectiveness Monitoring**

The effectiveness of the Phase 2 caps with respect to chemical isolation will be monitored based on a limited coring program in "sentinel areas." This effort will provide field data verifying the basic design assumptions for the cap (*i.e.*, whether diffusion or advection are the only significant drivers for contaminant migration upward into and through the cap at certain reaches) and a verification of the effectiveness of the cap to control chemical migration. Such monitoring of the chemical isolation layer in caps is similar to the planned long-term operation, monitoring and maintenance activities at other sediment sites like the Fox River and Lake Onondaga. Data on long term effectiveness will also allow for a determination whether any observed surface contamination is due to recontamination or from chemical migration through the caps.

The sentinel areas considered for the monitoring should be based on areas with the higher range of PCBs underlying the cap and other critical conditions that may exist in certain reaches of the river (*e.g.*, high groundwater upwelling rates). EPA will select up to six sentinel areas for chemical isolation monitoring and provide GE with the boundaries of the capped areas selected for this monitoring. The selection will be made following completion of the Phase 2 dredging work, or five years after Phase 2 dredging begins, whichever occurs first.

Chemical isolation monitoring shall be carried out by GE. The initial chemical isolation monitoring effort shall occur in the 10th year following construction of the first sentinel cap area among those selected for monitoring or as soon as practical after a flood event with a magnitude at or exceeding the design recurrence interval for the cap, whichever is earlier. Monitoring of all sentinel cap areas will be conducted in the same year. Subsequent efforts will be conducted at 10-year intervals or as soon as practical after flood events with a magnitude at or exceeding the design recurrence interval for the cap, whichever is earlier, and this chemical isolation layer monitoring may be terminated after 30 years, or at EPA's discretion, a time interval in which the monitoring results are determined by EPA to confirm design predictions.

Each monitoring effort will consist of a minimum of 20 cores per sentinel area. Cores shall be taken through the caps and a minimum of 2 feet into the underlying sediments, to native clay, or to bedrock, whichever is less. Cores shall be segmented for analysis based on visual inspection. A minimum of two core segments shall be taken from within the chemical isolation layer of the cap, one in the upper 3 inches of the isolation layer, and one from 3 inches to 6 inches above the bottom of the chemical isolation layer. These core segments, plus one from the upper portion of the underlying sediments will be analyzed for PCBs. Results of the analysis will be compared to prior baseline information collected at the completion of cap construction. The results will be reported to EPA within 15 days of sample collection.

3.3 Reporting

Data collected in conjunction with the cap monitoring shall be included in GE's monthly reports under the RA CD. If repairs are necessary based on the monitoring, GE shall submit a letter report to EPA, within two weeks of determining the need for such cap repairs, setting forth the proposed scope and schedule for such repairs. The objective will be to be complete the repairs in the same year that monitoring is performed (*i.e.*, before the canal closes in early November, if possible). In addition, GE shall provide annual cap OM&M summary reports to EPA that document the prior year's OM&M activities. The

annual reports shall include data collected from the cap OM&M field activities (including bathymetric survey results, critical field observations, and other analyses conducted) and any repair actions undertaken. The annual reports shall be submitted by April 1 of the year following the monitoring and maintenance activities described.

4. Monitoring and Maintenance of Habitat Replacement/Reconstruction

4.1 Introduction

This section describes requirements regarding the operation, maintenance, and monitoring program related to:

1. Shoreline stabilization and other stabilization measures installed within dredge areas;

2. The adaptive management-benchmark phase of habitat replacement/reconstruction evaluation; and

3. The success criteria phase of habitat replacement/reconstruction evaluation.

As stated in the ROD (USEPA 2002, p. A-3), "a habitat replacement program will be implemented in an adaptive management framework to replace SAV communities, wetlands, and river bank habitat" that are impacted by implementation of the remedy. Adaptive management is an iterative process of monitoring and natural engineering designed to bring habitat replacement and reconstruction activities to closure. The Phase 2 habitat replacement/reconstruction program includes replacement or reconstruction of three habitat categories: unconsolidated river bottom [UCB], submerged and floating aquatic vegetation [SAV], and riverine fringing wetlands [RFW].

For Phase 2 natural shoreline [SHO] areas, replacement and reconstruction shall consist of installation of backfill and other stabilization measures and shall continue with subsequent evaluations of the physical stability and vegetative integrity, as appropriate, of all installed measures under OM&M. This means that Phase 2 SHO areas will not be assessed as habitats with an adaptive management (*e.g.*, benchmark / response actions and success criteria) phase of evaluation. Phase 2 SHO areas replacement and reconstruction shall be evaluated through monitoring of physical and vegetative parameters. The goal of monitoring and maintenance of shoreline stabilization and other stabilization measures installed within dredge areas is to ensure the physical stability and vegetative integrity of:

1. Shoreline stabilization measures installed either above or below the design shoreline (*i.e.*, for River Section 1 = 119 feet NAVD88. The equivalent design shoreline elevations for other reaches in River Sections 2 and 3 will be defined in the Phase 2 *Final Design Report*.); and

2. Other stabilization measures (*e.g.*, coir fabric or "wave break" berms installed at RFW reconstruction areas and adjacent areas).

Monitoring requirements for OM&M of shoreline stabilization and other stabilization measures and associated response actions and performance standards attainment are described in Section 4.2 (below) and shall apply from the time of installation.

As stated in the Habitat Delineation and Assessment (HDA) Work Plan (BBL 2003a), which was part of the August 2003 Administrative Order on Consent for Remedial Design (RD AOC), "[t]he primary goal of the habitat 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 EPA selected remedy" (page 1-2). The range of functions shall be defined by parameters monitored at appropriate reference locations. The overall goal of the adaptive management process is to return a range of conditions in the replacement and reconstruction areas that overlaps with the range in the reference areas. Ultimately, this will be determined through the application of success criteria to habitat replacement and reconstruction areas in Phase 2. Phase 2 habitat replacement and reconstruction success criteria shall be described in the Phase 2 Final Design Report.

In accordance with the HDA Work Plan, the range of functions found in the Upper Hudson River was assessed during remedial design through measurement of certain parameters, in the above-referenced habitat types, that are related to the ecological functions provided by those habitat types. These assessments involved direct measurements of specified physical and biological parameters that are used to quantify the selected habitat functions. Those parameters are listed in Section 4.3.2 below (taken from Table 2 of the HDA Work Plan, with certain additional parameters added). The concept that these types of parameters can be used to quantify ecological functions was established in the HDA Work Plan, and is a founding principle of the hydrogeomorphic (HGM) approach (Shafer and Yozzo, 1998; Ainslie et al., 1999; Smith and Wakeley, 2001; Clairain, 2002) and habitat evaluation procedures (*e.g.*, Habitat Suitability Indices [HSIs]). It should be noted that while these parameters consist largely of structural parameters, some of them are also functional parameters. For example, the biomass of aquatic vegetation is not only a structural parameter, but also a functional parameter demonstrating aquatic vegetation bed productivity. Similarly, plant species composition measured in aquatic vegetation and fringing wetland habitats is a structural parameter, but is also a functional parameter relating to habitat diversity.

The habitat assessment program established the range of the parameters listed in Section 4.3.2 in the Upper Hudson River habitats prior to dredging, by measuring those parameters both in areas that will be directly impacted by dredging and those that will not. Based on those data, the specific parameters (from among those measured) to be used as design criteria for the habitat replacement and reconstruction program will be selected to achieve the above objective. These parameters will generally include parameters such as substrate type, shoot/stem density, percent cover, plant species composition, slope, water depth, *etc.*, and exclude parameters that cannot be "designed" (*e.g.*, those related to water quality, such as pH, temperature, specific conductivity, dissolved oxygen, turbidity). Design parameters will be specified in the Phase 2 Final Design Report.

The habitat assessment data will be used to develop "bounds of expectation" for the replaced and reconstructed habitats for use in design, and a suite of adaptive management techniques will be identified for use in the long-term monitoring and adaptive management program (discussed below). The Phase 2 habitat replacement and reconstruction program shall be designed to establish, through active and/or passive methods, an overall mix of habitats in the remediated portions of the river, taking account of physical constraints in the post-dredging environment, that is similar to the mix of habitats types in the pre-dredging and non-dredge (reference) portions of the river, and to return the overall distribution of the relevant parameters within the dredged areas to be similar to the overall distribution of such parameters in the reference areas (as described in Section 4.3 below), accounting for habitat size.

The overall mix of habitats will be established during the design. It is anticipated that comparisons of the range of conditions in reference and remediated areas will be made by statistical and other analytical tests appropriate for the collected data and agreed upon by GE and EPA or, in the absence of such an agreement, that are determined by EPA. The appropriate spatial scale for these comparisons will be determined by the data, and may consist of comparisons on a growing- season (i.e., year of installation) basis, a reach basis, or on an overall river-section basis for SAV and UCB habitat replacement and reconstruction areas; and may consist of individual areas comparisons for RFW habitat replacement and reconstruction areas. The spatial scale for these comparisons and the specific statistical or other analytical techniques to be used in the comparisons will be included in the Phase 2 Habitat Adaptive Management Plan (Habitat AMP), which will be part of the Phase 2 *Final Design Report*, subject to revision for each year of Phase 2.

4.2 Shoreline Stabilization and Other Stabilization Measures Monitoring and Maintenance

Natural shorelines shall be maintained where practicable (*i.e.*, the "default" shoreline stabilization measure is installation of near-shore backfill). Shoreline stabilization and other stabilization measures installed within Phase 2 dredge areas includes the use of planted material, biologs, coir fabric, backfill, or placement of rip rap to stabilize riverbanks, shorelines, and habitat replacement and reconstruction areas as needed. For Phase 2 these measures are proposed to be installed in the year of dredging/backfilling. Review and initial approval (*i.e.*, designation of installed measures as "temporary") of all Phase 2 shoreline stabilization and other stabilization measures shall be conducted through CU Certification Form 2. The subsequent designation of shoreline stabilization and other stabilization measures as "permanent" shall be conducted through CU Certification Form 3. Upon certification through the Form 3 review process, shoreline stabilization and other stabilization measures shall proceed to long-term OM&M. If at any time during OM&M, monitoring or observations indicate that specific response actions are necessary to prevent or halt specific problems such as bank slope failure where structural integrity is needed to support the permanence of the stabilization measure, and/or the infrastructure or habitat that is supported by such measures, GE shall implement such response actions.

4.2.1 Data Quality Objectives

GE shall develop and present DQO's for shoreline stabilization and other stabilization measures installed within dredge areas in the Phase 2 OM&M Plan.

4.2.2 Data Collection

GE shall present data collection standards for shoreline stabilization and other stabilization measures installed within dredge areas in the Phase 2 OM&M Plan.

4.2.3 Monitoring Frequency

Monitoring of the installed stabilization measures shall be conducted monthly (or more frequently if conditions indicate) within the year of installation and annually (or more frequently if conditions indicate) thereafter.

4.2.4 Performance Standards

Physical and vegetative performance standards for monitoring of shoreline stabilization and other stabilization measures,, including monitoring thresholds, response actions, and performance standards attainment for the purpose of terminating shoreline stabilization and other stabilization measures OM&M shall be described in Phase 2 *Final Design Report*.

4.3 Post-Certification Monitoring Components

Following dredging, the habitat replacement/reconstruction designs shall be implemented in accordance with the approved Phase 2 final design. Upon certification of completion of the remedial activities related to initial planted material installation (*i.e.*, CU Certification Form 3 approval) in each CU, OM&M (*i.e.*, post-certification monitoring), including evaluation through adaptive management, shall commence. In certain cases, monitoring under the adaptive management phase may proceed for specific habitats located within CUs where not all habitat work can be deemed complete (*e.g.*, as was the case with RFW habitat reconstruction areas during Phase 1).

Post-certification habitat monitoring and adaptive management will consist of the following components:

1. Adaptive management-benchmark evaluation phase; and

2. Success criteria evaluation phase.

4.3.1 Data Quality Objectives

In the post-remediation environment, habitat monitoring and adaptive management become complementary, as these two processes serve to gauge the recovery of habitat at the appropriate spatial scale. When combined, monitoring and adaptive management form the mechanism for making management changes, as such changes are warranted, to the course of habitat recovery. In this context, the data quality objectives for the post-construction monitoring of habitat replacement/reconstruction measures are to:

1. Evaluate whether, and to what extent, the replacement/reconstruction of habitat in a given river reach is achieving the goal of replacing the habitat functions, as measured by the parameters listed in Section 4.2.3, to within the range found in similar physical settings in the Upper Hudson River, given changes in river hydrology, bathymetry, and geomorphology resulting from the remedy, as well as from other factors; and

2. Provide the basis for sound adaptive management decision making in support of attainment of the success criteria for each habitat. Thresholds, or benchmarks and response actions for each habitat shall be described in the Phase 2 Habitat AMP and will reflect the various spatial scales of comparison for each habitat. These response actions shall be evaluated through the use of success criteria to ensure attainment of habitat replacement/reconstruction goals.

4.3.2 Data Collection

Sampling of the replaced and reconstructed unconsolidated river bottom, aquatic vegetation bed, and riverine fringing wetland habitats shall be conducted annually, between June 1 and September 30, and

shall focus on peak growth times for aquatic vegetation and wetlands. Habitat-specific sampling windows are discussed in the HDA Work Plan (on pages A-3, B-5, C-3 and D-4) but should remain flexible and be subject to adjustment based on seasonal variations in factors affecting the plant communities within the RFW, SAV, and UCB habitats as agreed upon by EPA and GE or, in the absence of such an agreement, that are determined by EPA. Data shall be collected from both target (dredged) and unimpacted (non-dredge area) stations for each habitat in accordance with the standard operating procedures provided in the HDA Work Plan. Collected data shall be evaluated on an ongoing basis (at a minimum, annually) to determine if modifications to the sampling design are warranted. The following parameters shall be sampled in each habitat, including backfilled or capped areas:

1. Unconsolidated River Bottom (UCB)

    - substrate type;
    - epifaunal substrate and cover;
    - total organic carbon;
    - temperature;
    - dissolved oxygen;
    - specific conductivity;
    - pH;
    - turbidity;
    - percent fines;
    - embeddedness; and
    - downfall.

2. Submerged Aquatic Vegetation (SAV) beds

    - total organic carbon;
    - shoot density;
    - percent cover;
    - shoot biomass;
    - plant species composition (including percent nuisance species);
    - sediment nutrient availability;
    - light availability;
    - water depth;

- current velocity;
- temperature;
- dissolved oxygen;
- specific conductivity;
- pH;
- turbidity;
- percent fines; and
- downfall.

3. Riverine Fringing Wetlands (RFW)
    - stem density;
    - stem length;
    - stem thickness;
    - soil properties;
    - percent cover;
    - shoot biomass;
    - plant species composition (including percent nuisance species);
    - slope;
    - water depth/inundation;
    - water temperature;
    - dissolved oxygen;
    - specific conductivity;
    - pH;
    - turbidity;
    - area;
    - wetland edge
    - area of buffer; and

- percent contiguous with other habitats.

In addition to the above-listed parameters, fish and wildlife observational and other data may be collected in any of the habitat replacement/reconstruction areas as direct measurements of habitat functions. The purpose of these data shall be: (a) to serve as the basis for applying secondary success criteria (as discussed in Section 4.5 below), or (b) to guide adaptive management decision-making as agreed upon by EPA and GE or, in the absence of such an agreement, that are determined by EPA, if the primary criteria do not provide sufficient insight. Additional parameters may also be added under the adaptive management framework.

4.3.3 **Sampling Locations**

Data shall be collected from both dredged and non-dredged locations. To evaluate success of the habitat replacement and reconstruction program after its implementation -- given the changes in river hydrology, bathymetry, and geomorphology that will 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 shall be used as post-remediation reference sites. In addition, one or more off-site reference stations within the upstream Upper Hudson River (Sherman Island hydroelectric plant to west city limits of Glens Falls) and the Lower Mohawk River (Lock 7 to Route 9 Marina) will be included as reference sites in the database for the project area. These areas will 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 off-site reference areas will be used to evaluate the impacts (if any) of potential broad, watershed-wide or regional changes unrelated to the remediation project that may extend beyond the 40-mile project area, and to determine whether these changes have had an effect on habitat replacement/reconstruction.

The overall sampling design described in the HDA Work Plan, including the number and location of target and non-dredge area monitoring stations shall provide the basis for initial Phase 2 post-remediation monitoring activities. For the purpose of determining initial Phase 2 stations for post-remediation (*i.e.*, post-certification) monitoring, the completion of remediation shall be determined by CU Certification Form 3 approval. As part of the CU Certification Form 3 review process, candidate post-certification monitoring stations shall be identified within each habitat replacement/reconstruction area located within the CU. GE shall propose a rationale for the identification of post-certification monitoring stations in the *Phase 2 Final Design Report.* These candidate stations shall be identified to facilitate monitoring during the adaptive management-benchmark (AMP-benchmark) phase of habitat replacement/reconstruction evaluation. Evaluation under the AMP-benchmark phase of habitat replacement/reconstruction monitoring shall begin in the year following CU Certification Form 3 approval. It is anticipated that the AMP-benchmark monitoring stations will also be those monitored as part of success criteria monitoring and evaluation. GE shall propose the final number and location of post-certification monitoring stations for each river reach to EPA for approval prior to the initiation of success criteria monitoring and evaluation within each River Section.

4.4 Phase 2 Success Criteria

EPA and GE will discuss and further develop success criteria, subject to EPA approval, for Phase 2 based on the results of Phase 1 success criteria derivations for each habitat type. If GE and EPA cannot reach agreement, the success criteria shall be determined by EPA. For each of the Phase 2 habitat replacement

and reconstruction categories that will be subject to evaluation (*i.e.*, UCB, SAV, and RFW) success criteria shall be described in the *Phase 2 Final Design Report*. In addition, for each of these Phase 2 habitat replacement and reconstruction categories, candidate reference monitoring stations for each river reach and river section shall be described in the *Phase 2 Final Design Report*. Final Phase 2 habitat replacement/reconstruction reference monitoring stations shall be described in the *Phase 2 Adaptive Management Plan*.

If the primary success criteria are not met within the appropriate spatial extent, data that directly measure the relevant functions (*e.g.*, presence and abundance of fish and/or wildlife species), to the extent available, may be used as secondary success criteria. Secondary success criteria may also be used to guide adaptive management decision-making. The available data directly measuring functions (*e.g.*, fish and/or wildlife presence) shall be reviewed as a secondary measure for evaluating success; and if those data in dredged areas fall within the range of those in the reference areas, and if the data are sufficient to indicate that such conditions are likely to be sustainable, then the habitat replacement/reconstruction shall be considered successful. The information on the presence of biota including fish and wildlife shall be obtained from observations conducted under the HDA program (if any), biological data collected under other remediation programs (*e.g.*, fish information from the BMP), or additional data, that are agreed upon by GE and EPA as appropriate, and collected under the OM&M program. In the absence of agreements regarding additional data needs, these data needs will be determined by EPA.

4.5 Adaptive Management Measures for the Habitat Replacement/Reconstruction Program

Natural engineering, including self-design (by which the ecosystem itself optimizes its recovery, Mitsch 2000), is fundamental to the success of the adaptive management program. As noted above, the parameters listed in Section 4.3.2 (above) shall be the primary measures to define habitat replacement and reconstruction and control the recovery trajectories. Active and passive habitat replacement/reconstruction shall be incorporated into the design documents. In some situations, initial active or passive approaches may be insufficient to achieve success criteria or the recovery trajectory may be below expectations. In such situations, corrective action measures may need to be implemented in the form of adaptive management measures.

In the short term, if monitoring or observations indicate that specific measures are necessary to prevent or halt specific problems such as bank slope failure where structural integrity is needed to support infrastructure or habitat, GE shall implement such measures. The AMP-benchmark phase of habitat replacement/reconstruction evaluation will also inform the need for such short term measures. In the longer term, adaptive adjustments may be necessary to support the natural engineering process. Evaluations to determine whether any longer-term adaptive adjustments are needed will be made on a yearly basis. In deciding whether, how, and when to undertake such adjustments, the adaptive management program shall incorporate a logical sequence of iterative assessment and adjustment steps intended to maximize habitat recovery while minimizing human interference with natural engineering processes. In summary, the sequence shall: (1) acknowledge and account for lag times following implementation, *i.e.*, that habitat recovery may take one or more years to reach the intended trajectory due to ecological processes, habitat type, and/or the extent of changes that the river will undergo during remediation; (2) determine if a problem exists; and (3) determine the appropriate action. The appropriate

actions shall be based on the nature and extent of the identified problem(s) (*e.g.*, shoot density in replaced/reconstructed aquatic vegetation bed is below that in the reference beds), and may include continuation of monitoring, adjustment of site-specific goals (*e.g.*, a portion of the site may no longer be suitable for aquatic vegetation and thus the goals for that area would need to be altered, and if warranted, corrective measures would be taken), or implementation of a field response action. For the OM&M activities under this Scope, field response actions shall consist of the following:

1. Invasive species management in replaced/reconstructed areas to maintain the extent of invasive species below specific levels (*e.g.*, maximum percent of a site) as specified in the *Phase 2 Final Design Report*. This field response action does not include the complete elimination of invasive species from replaced/reconstructed areas unless specified as a response action under the AMP. Area-specific invasive species control and management plans shall assess the applicability of post-control plantings (*i.e.*, in the event that an invasive species removal action results in barren ground). Acceptable species for post-control planting, as agreed upon by EPA and GE or, in the absence of such an agreement, that are determined by EPA, will be included in the contract specifications. The overall invasive species management program (*i.e.*, including activities proposed both during dredging/backfilling and after dredging/backfilling and during OM&M) will be fully described in the *Phase 2 Final Design Report*.

2. Targeted plantings in SAV and RFW habitat reconstruction areas. This field response action does not include complete replanting of a site unless the cause(s) for the initial failure of the plantings has been identified and corrected/controlled. This field response action will be fully described in the *Phase 2 Adaptive Management Plan* that will accompany the *Phase 2 Final Design Report*.

3. Maintenance of habitat replacement/reconstruction structures consistent with design specifications and as appropriate under the *Phase 2 Adaptive Management Plan*.

4. Actions to respond to the impacts of unforeseen anthropogenic (*i.e.*, non-natural events), as agreed upon by GE and EPA or, in the absence of such an agreement, that are determined by EPA and as appropriate under, and consistent with, the *Phase 2 Adaptive Management Plan*.

In addition, and based on field experience, additional actions may be required, as agreed upon by GE and EPA. In the event that GE and EPA cannot agree, EPA shall make determinations regarding additional response actions.

This OM&M program shall not require the implementation of changes in the type of habitat from the types designed and implemented as part of the habitat replacement/reconstruction program. Further details on the adaptive adjustment measures will be provided in the *Phase 2 Adaptive Management Plan*.

4.6 Reporting

Habitat monitoring data that are collected as part of this OM&M program shall be used to evaluate the success of habitat recovery through evaluation of that recovery with primary, or as needed secondary, success criteria. During this OM&M program, GE shall provide the data from the program to EPA, inclusive of data files, shape files, and photo-documentation, in the monthly reports and monthly database updates under the Consent Decree. In addition, GE shall submit annual *Monitoring, Maintenance, and*

Adaptive Management Reports to EPA by January 31 of each year. Each such report shall present the habitat monitoring data collected during the previous calendar year(s) under any of the monitoring components described in Section 4.1 (above) and the results of any response actions or adaptive management evaluations (including trend analyses) performed during that year.

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