Monitoring and Adaptive Management Plan for *Deepwater Horizon* NRDA Project:

Lake Borgne Marsh Creation Project - Increment 1

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Final Version Date: 9/8/2020

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1 Introduction

The Deepwater Horizon (DWH) Louisiana Trustee Implementation Group (TIG) developed this Monitoring and Adaptive Management Plan (Plan) for the Lake Borgne Marsh Creation Project – Increment 1 (Lake Borgne Project), which represents one of six projects selected from within the broader Final Restoration Plan #1: Restoration of Wetlands, Coastal, and Nearshore Habitats; Habitat Projects on Federally Managed Lands, and Birds in January 2017. The purpose of this Monitoring and Adaptive Management (MAM) Plan is to identify monitoring activities that will be conducted to evaluate and document restoration effectiveness, including performance criteria for determining restoration success or need for interim corrective action (15 CFR 990.55(b)(1)(vii)). Where applicable, the MAM Plan identifies key sources of uncertainty and incorporates monitoring data and decision points that address these uncertainties. It also establishes a decision-making process for making adjustments where needed.

There are three primary purposes for MAM Plans:

1. Identify and document how restoration managers will measure and track progress towards achieving restoration goals and objectives;

2. Increase the likelihood of successful implementation through identification, before a project begins, of potential corrective actions that could be undertaken if the project does not proceed as expected;

3. Ensure the capture, in a systematic way, of lessons learned or new information acquired that can be incorporated into future project selection, design, and implementation.

The MAM Plan is a living document and may be updated as needed to reflect changing conditions and/or new information. For example, the MAM Plan may need to be revised should the project design change, if initial data analysis indicates that the sampling design requires adjustment, or if any uncertainties are resolved or new uncertainties are identified during project implementation and monitoring. Any future revisions to the MAM Plan will be made publicly available through the Restoration Portal via the following link: (https://www.diver.orr.noaa.gov/web/guest/home) and accessible through the Deepwater Horizon NRDA Trustees website via the following link: (https://www.gulfspillrestoration.noaa.gov/).

1.1 Project Overview

The Lake Borgne Marsh Creation Project – Increment 1 is located in St. Bernard Parish, Louisiana between the southwestern shoreline of Lake Borgne and Mississippi River Gulf Outlet (MRGO) (Figure 1). The Lake Borgne Project will restore approximately 2,816 acres of degraded intertidal marsh through strategic placement of dredge material (Figure 1). It is anticipated that the initial construction elevation of the marsh platform will be approximately +3.5 feet (NAVD88). Sediment for the marsh will be dredged from the southern portion of Lake Borgne. Upon completion of the project, suitable native herbaceous vegetation is expected to naturally become established within the first few years. However, vegetative plantings on the marsh platform may occur if natural succession does not occur as anticipated (see Section 5 on corrective actions).

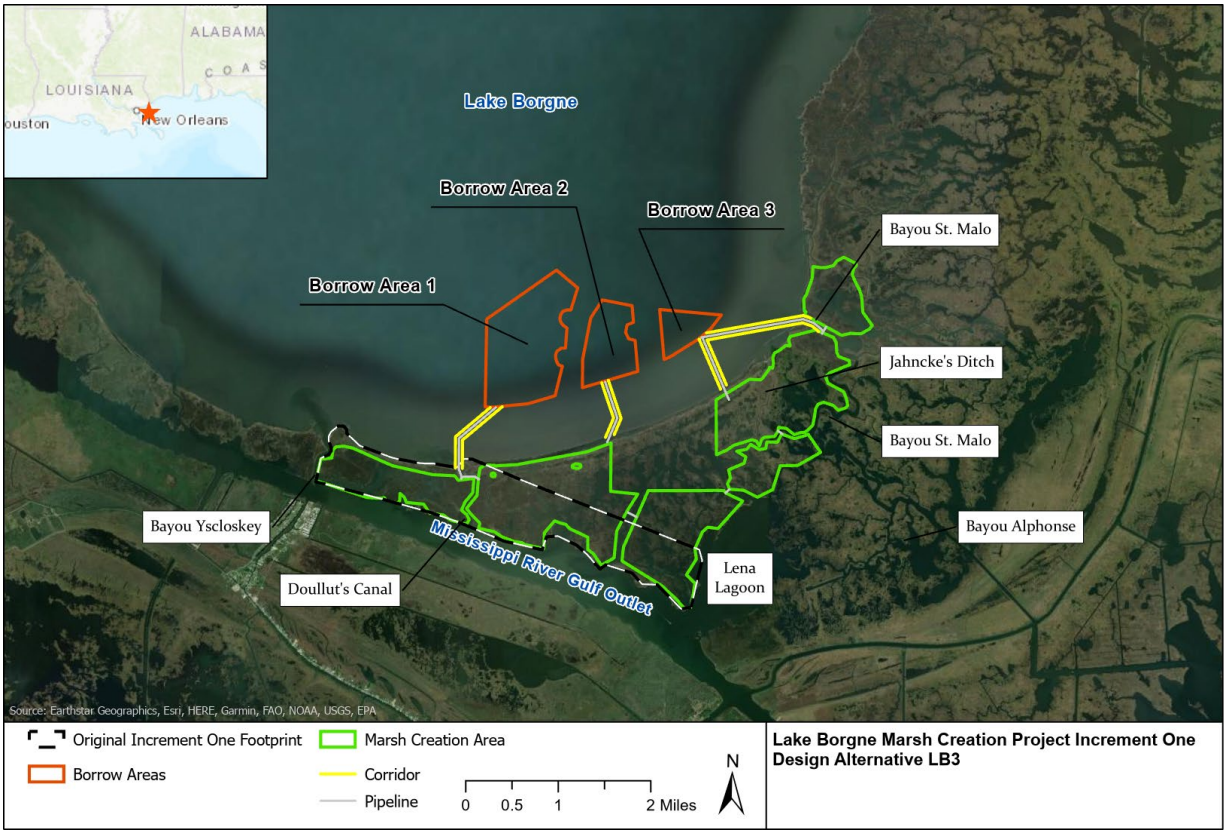

Figure 1. Lake Borgne Project Marsh Creation.

The Lake Borgne Project is being implemented as restoration for the *Deepwater Horizon* oil spill Natural Resource Damage Assessment (NRDA), consistent with the PDARP/PEIS (Deepwater Horizon Natural Resource Damage Assessment Trustees. 2016). Per the PDARP/PEIS, the project falls into the following restoration categories:

- **Programmatic Goal:** Restore and Conserve Habitat
- **Restoration Type:** Wetlands, Coastal, and Nearshore Habitats
- **Restoration Approach:** Create, Restore, and Enhance Coastal Wetlands
- **Restoration Technique:** Create or enhance coastal wetlands through placement of dredged material
- **Trustee Implementation Group:** LA TIG
- **Restoration Plan:** Louisiana Trustee Implementation Group Final Restoration Plan #1.2: Barataria Basin Ridge and Marsh Creation Project Spanish Pass Increment and Lake Borgne Marsh Creation Project Increment One

The implementing state trustee is the Coastal Protection and Restoration Authority (CPRA) of Louisiana. The implementing federal trustee is the United States Department of Interior, represented by the U. S. Fish and Wildlife Service (USFWS).

1.2 Restoration Type Goals and Project Restoration Objectives

The goal for the Project is to create and restore wetlands, coastal and nearshore habitats in the Louisiana Restoration area (LA TIG, 2017) specifically along the Lake Borgne shoreline. This area has been degraded due to eustatic sea level rise, high subsidence rates, reduced sediment supply, and wave action. In restoring these coastal habitats, the Trustees envision that the Project will compensate, in part, for wetlands, coastal and nearshore habitat losses associated with the spill.

1.2.1 Restoration Type Goals

As summarized in the PDARP/PEIS, Chapter 5, the restoration goals for injuries to coastal habitats are as follows:

- Restore a variety of interspersed and ecologically connected coastal habitats in each of the five Gulf states to maintain ecosystem diversity, with particular focus on maximizing ecological functions for the range of resources injured by the spill.
- Restore for injuries to habitats in the geographic areas where the injuries occurred, while considering approaches that provide resiliency and sustainability.
- Restore habitats in appropriate combinations for any given geographic area. Consider design factors, such as connectivity, size, and distance between projects, to address injuries to the associated living coastal and marine resources and restore the ecological functions provided by those habitats.

1.2.2 Project Restoration Objectives

To help meet the restoration goals for injuries to coastal habitats, the project restoration objective is to create approximately 2,816 acres of new marsh habitat along the southern margin of Lake Borgne, which has been degraded due to sea-level rise, high subsidence rates, diminished sediment supply, and extreme storm events. The degree to which this restoration objective is met, as well as documentation of any collateral impacts from the project, will be evaluated via measurements of the following parameters:

- Parameter #1: Spatial Extent (acres) of marsh creation
- Parameter #2: Elevation of marsh areas
- Parameter #3: Vegetative Cover
- Parameter #4: Invasive Species Cover
- Parameter #5: Gulf Sturgeon Telemetry
- Parameter #6: Water Quality
- Parameter #7: Benthic Macroinvertebrate Recolonization
- Parameter #8: Borrow Area – Infilling Rate
- Parameter #9: Modeling

These parameters will be monitored according to the monitoring schedule summarized in Section 2. Throughout the design process, project team members, including the CPRA, the Louisiana Department of Wildlife and Fisheries (LDWF), the National Oceanic and Atmospheric Administration (NOAA), and the USFWS will have the opportunity to refine design parameters as additional information becomes available. Performance criteria will be identified/implemented to determine restoration success or the

need for corrective action in accordance with 15 CFR 990.55(b)(1)(vii)). Specific, measurable performance criteria are defined for monitoring parameters associated with each of the restoration objectives in Section 5.0.

1.3 Conceptual Setting

The Lake Borgne Project is located adjacent to the MRGO approximately 30 miles east-southeast of New Orleans, in St. Bernard Parish, Louisiana. Historically, the marshes in this part of Louisiana received freshwater, nutrients, and sediments from the Mississippi River through distributary channels and overbank flooding events. However, the Mississippi River levees have isolated these wetlands from these replenishing sediments; combined with coastal erosion and sea level rise, these factors have caused significant degradation of these marshes. Marsh creation projects like the one proposed here could help to build and maintain these habitats through time. Additional information about the conceptual setting for the Lake Borgne project is summarized in Section 2.2.2 of the *Louisiana Trustee Implementation Group Final Restoration Plan #1* (LA TIG 2017) and is incorporated here by reference.

1.3.1 Potential Sources of Uncertainty

Although the likelihood of project success is evaluated under the OPA regulations (15 CFR § 990.54(a)(3)), uncertainties may exist regarding how to best implement projects to achieve the greatest benefits for the injured resources. These uncertainties may arise from an incomplete understanding of the current conceptual setting; from unknown conditions in the future; or from project elements that do not perform as anticipated (e.g., sediment compaction or vegetation success). For the Lake Borgne marsh creation project, the uncertainties summarized in Table 1 could affect project success and could therefore be key drivers of corrective actions or adaptive management decisions. Sections 2 through 3 summarize project monitoring data and describe how this information will be used to inform adaptive management to address these uncertainties.

Potential uncertainties are defined as those that may affect the ability to achieve stated project restoration objective(s). To aid in the identification of uncertainties, Trustees utilized a variety of sources, including but not limited to PDARP/PEIS Restoration Type MAM sections (Deepwater Horizon Natural Resource Damage Assessment Trustees. 2016), *Monitoring and Adaptive Management Procedures and Guidelines Manual Version 1.0* (*Deepwater Horizon* (DWH) Natural Resource Damage Assessment Trustees. 2017), and other documents. Select monitoring activities can then be implemented to inform these uncertainties and to select appropriate corrective actions in the event the Project is not meeting its performance criteria (Table 1).

Table 1. Key Uncertainties.

Reference Number	Key Uncertainty	Description on How the Uncertainty Could Impact Project Success and/or Decision-Making
1	Sea level rise, subsidence, sediment compaction	Increased flooding of the marsh platform would reduce the growth and cover of herbaceous plant species and increase the coverage of submerged aquatic species or increase the open-water area.
2	Success of vegetation establishment/plantings	Lack of vegetation establishment/planting success would limit or delay the creation of the desired habitat.

Reference Number	Key Uncertainty	Description on How the Uncertainty Could Impact Project Success and/or Decision-Making
3	Herbivory	Young tender plants, either through natural succession or vegetative plantings, are desired by some species as a source of food. Herbivory may cause the increase of planting efforts by requiring devices to reduce plant consumption. Also, would delay the establishment of vegetation and habitat creation.
4	Impact on Gulf Sturgeon	Dredging will take place in Critical Habitat for Gulf Sturgeon. It is not known whether Gulf Sturgeon use these areas for foraging for benthic prey. Furthermore, it is not known whether borrow areas will alter water quality conditions relative to undisturbed areas or the long-term impacts to substrate composition and/or benthic invertebrates.

2 Project Monitoring

The MAM Plan was developed to evaluate project performance, key uncertainties, and potential corrective actions, if needed, for the first 5 years after the project's construction. The data collected during this 5-year period will also be used to predict the project's performance during the remaining years of the project's design life (20 years total). This section summarizes the project monitoring parameters that will be used to evaluate performance through time. For each of the identified monitoring parameters, information is provided as to its intended purpose (e.g., to monitor progress toward meeting the restoration objectives or to support adaptive management of the project), monitoring methods, timing and frequency, duration, sample size, and sites. Further, these parameters will be monitored to demonstrate how the restoration project is trending toward the performance criteria and to inform the need for corrective actions (see Section 5, Project-Level Decisions).

The *Monitoring and Adaptive Management Procedures and Guidelines Manual Version 1.0* (Deepwater Horizon (DWH) Natural Resource Damage Assessment Trustees. 2017) recommends project-level monitoring be conducted at reference or control sites. The CPRA currently maintains a monitoring program that provides ecological data and research to support the planning, design, construction, evaluation, and adaptive management of Louisiana's wetland restoration projects (Folse et al. 2018). This Coast-wide Reference Monitoring System-Wetlands (CRMS) was developed and implemented to improve the monitoring program's effectiveness in evaluating individual restoration projects, as well as the combined effects of multiple projects by providing a network of reference sites where data are collected on a regular basis (Steyer et al. 2003). There are two CRMS-Wetland sites, CRMS4548 and CRMS4551, located within the project boundary and another two sites, CRMS3800 and CRMS4557, within 5 miles of the Project which have been collecting data since 2006. Vegetation, Rod-Surface Elevation Table (RSET), accretion, and hydrologic data from these CRMS sites will be used as reference sites to monitor project success.

Though additional measures may be implemented to more fully characterize the Project's effectiveness, the LA TIG proposes the continued implementation of proven and established monitoring methodologies to monitor project success:

- Parameter #1: Spatial Extent (acres) of marsh creation
  a) Purpose: To determine how many acres of marsh were created and the change in marsh area through time
  b) Method(s): Acquire and orthorectify high-resolution, near-vertical aerial imagery
  c) Timing, Frequency, and Duration: YR 0 - immediate post-construction/as-built will occur soon after construction activities conclude; Years (YRs) 3 and 5 post-construction - will occur during the Fall of the respective years
  d) Sample Size: Aerial imagery will be acquired for the entire project area and some surrounding areas
  e) Sites: Project area

- Parameter #2: Elevation of marsh
  a) Purpose: To determine that the average elevation is achieved per the design specifications for construction and to verify the elevation of the sediment is as expected per the design curves in the final design report at YRs 3 and 5 post-construction.
  b) Method: LiDAR and/or RTK topographic surveys
  c) Timing, Frequency, and Duration: Surveys will be conducted during construction (before and after sediment placement) and at YRs 0, 3, and 5 post-construction.
  d) Sample Size: Construction surveys will be conducted on transects spaced every 250 feet apart or as specified in the construction documents. YR 0 would utilize LiDAR and/or RTK as little to no vegetation is expected. YRs 3 and 5 transects will be spaced either 500, 750, or 1,000 feet apart.
  e) Sites: Throughout the project area

- Parameter #3: Vegetative Cover
  a) Purpose: To determine the vegetative percent cover in the marsh
  b) Method: Ocular estimates (Folse et al. 2018) using 2 meter by 2 meter plots randomly placed along transects through the project area. Includes cover and species present.
  c) Timing, Frequency, and Duration: YR 1 – after first growing season (if sediment consolidation allows access), YRs 3 and 5 post-construction. Sampling will occur between mid-August and mid-November with the target being September/October.
  d) Sample Size: To be determined
  e) Sites: Project area; CRMS sites and restoration projects having similar habitats will be used as references

- Parameter #4: Invasive Species Cover
  a) Purpose: To determine invasive species percent cover

b) Method: Ocular estimates (Folse et al. 2018) using 2 meter by 2 meter plots randomly placed along transects through the project area; same plots as Parameter #3: Vegetative Cover
c) Timing, Frequency, and Duration: Same as Parameter #3: Vegetative Cover
d) Sample Size: To be determined
e) Sites: Project area; CRMS sites and restoration projects having similar habitats will be used as references

- Parameter #5: Gulf Sturgeon Telemetry
  a) Purpose: To determine whether acoustically tagged gulf sturgeon use the portion of Lake Borgne where the Lake Borgne Marsh Creation – Increment 1 and the Golden Triangle Marsh Creation project's borrow areas are located.
  b) Method: Telemetry surveillance will include twenty (20) continuously recording receiver stations throughout the southern portion of Lake Borgne, including within and around the footprints of the Lake Borgne and Golden Triangle borrow locations. This sturgeon telemetry monitoring will be executed in conjunction with planned research efforts (i.e., Open Ocean sturgeon project) to leverage resources across multiple projects to complete a robust telemetry surveillance throughout Lake Borgne. These data collection efforts will be combined with information gathered through Parameters #6, #7, #8, and #9, which will develop a broad understanding of Gulf sturgeon occupancy in the Lake Borgne area.
  c) Timing, Frequency, and Duration: Continuously recording acoustic receivers will be deployed to provide passive monitoring of the project areas. The telemetry array would be deployed prior to the initiation of dredging operations, and would be maintained for approximately two years. The two-year period of analysis will include pre-construction conditions and a period of time during initial dredging activity. Receivers would be routinely downloaded and serviced every six to eight weeks, with water quality parameters concurrently recorded.
  d) Sample Size: Twenty acoustic receivers will be strategically deployed throughout the southern portion of Lake Borgne.
  e) Sites: The acoustic receivers would be deployed in a coarse-scale array covering the lower portion of Lake Borgne including the Golden Triangle and Lake Borgne marsh creation borrow areas. This effort will be coordinated with the Open Ocean TIG sturgeon acoustic tagging research project (which places receivers in upper Lake Borgne), thereby integrating telemetry monitoring efforts to cover the entire Lake Borgne area.

- Parameter #6: Water Quality
  a) Purpose: To measure water quality at various depths within and surrounding the Lake Borgne and Golden Triangle borrow areas to capture a before and after dataset of water quality parameters.
  b) Method: Water quality multi-probe sonde will be deployed from a boat to measure turbidity, temperature, pH, specific conductance, salinity, and dissolved oxygen at multiple depths and locations.

c) Timing, Frequency, and Duration: Discrete samples will be collected in conjunction with other sampling efforts in Parameters #5 (at each receiver site for every data download) and #7 (for each benthic sample). Additionally, routine monthly sampling will be conducted within and around each borrow area for at least one year following dredging completion. Sampling duration may be extended up to 5 years, and frequency may increase to every other week during summer if stratification or hypoxia is detected.
d) Sample Size: Approximately 20 locations with 3-4 depths measured at each location.
e) Sites: Collocated with benthic sampling and telemetry monitoring sites, as well as specifically within and adjacent to the four dredge borrow areas.

- Parameter #7: Benthic Invertebrate Recolonization
  a) Purpose: To evaluate pre- and post-dredging macroinvertebrate density and community composition to estimate the rate of post-dredging recolonization of the benthic community in relation to water quality and substrate composition.
  b) Method: Collect surficial benthic grab samples for biologic and substrate compositional analysis.
     - Quantify component grain size classes of substrate samples using graduated sieves to separate material into grain size classes representative of silt/clay (< 0.59 mm), sand (0.6 -1 mm), gravel (> 1 and < 16 mm), and larger (> 16 mm).
     - Calculate organic content (loss on ignition).
     - Conduct taxonomic identification and enumeration of benthic macroinvertebrates.
     - Collect water quality data (dissolved oxygen, salinity, turbidity, temperature) associated with each benthic sample location.
  c) Timing, Frequency, and Duration: Samples would be collected prior to dredging as a representative baseline, immediately after dredging is completed (year 0), and one year post-construction. If benthic recolonization is not observed in year 1, additional sampling may occur 3 and/or 5 years post-construction.
  d) Sample Size: Initial sampling locations would be collocated with the twenty telemetry receiver deployment sites throughout lower Lake Borgne, including within the planned borrow areas. Post dredging samples will be collected in quadruplicate for each of the borrow areas, and at non-disturbed control sites, during each sampling period to characterize benthic substrate and macroinvertebrate fauna (approximately 20 samples per period).
  e) Sites: Baseline benthic sampling will be located at the 20 acoustic receiver locations throughout lower Lake Borgne, including within dredge borrow areas. During each post-dredging sampling periods, quadruplicate samples will be collected from within each of the four dredge borrow footprints, as well as from adjacent control sites that will remain undisturbed by the project.

- Parameter #8: Borrow Area – Infilling Rate
  a) Purpose: To determine the rate of sediment infilling of the borrow area after dredging.
  b) Method: Single beam bathymetry survey

c) Timing, Frequency, and Duration: YRs 1, 3, and 5 post-construction
d) Sample Size: The survey will be completed on a 500 foot by 1,000 foot grid.
e) Sites: The borrow area plus transects extended beyond the borrow area for reference

- Parameter #9: Modeling
  a) Purpose: Numerical environmental models will be developed for the entire basin surrounding the project area including Lake Pontchartrain, Lake Borgne, the Biloxi Marsh area, out to Chandeleur Sound. In the first phase of development the models will use existing data for river stage, discharge, wind and ocean currents, precipitation, and physical landscape features to estimate environmental conditions in coastal estuaries that are important in providing suitable habitat for Gulf sturgeon. Once developed, the models will provide capacity to hind-cast aquatic environmental conditions based on historic information and to project future aquatic conditions based on various contemplated scenarios. The models will be used in a hind-cast role in the second phase of the project to provide estimates for historic conditions from 2016 to 2019. The modelled output will be combined with existing USFWS and LDWF telemetry data to develop habitat suitability maps that will provide managers with important quantitative information about Gulf sturgeon habitat in the area to inform current and future restoration projects. In the third phase, modeled output for Lake Borgne will be combine with telemetry information collected as part of the cooperative telemetry array to develop similar habitat suitability maps. Once complete, managers will have a quantitative assessment of the probability of Gulf sturgeon occupancy for the entire footprint of Gulf sturgeon critical habitat in Louisiana. The numerical models will continue to provide the capacity to derive environmental parameters like salinity, temperature, and dissolved oxygen on a daily timescale to evaluate potential biological response for many other species to various environmental changes.
  b) Method: Three additive phases of modeling will be conducted, culminating with the incorporation of the telemetry dataset collected via Parameter #5. Phase 1 of the modeling efforts will include the development of model conditions, and production of components that influence habitat suitability (environmental and physical conditions) at a basin-wide scale with a specific focus on the Lake Borgne area. Phase 2 will overlay past telemetry information into the numerical habitat model developed in the first phase, and hindcast sturgeon movement patterns based on three years of previous collected USFWS telemetry data. Phase 3 of modeling will update the model and re-run outputs with the incorporation of new sturgeon telemetry data collection efforts (i.e., Parameter #5) to forecast sturgeon habitat utilization and guide the development of future projects through adaptive management.
  c) Timing, Frequency, and Duration: The three phases of modeling will be conducted sequentially and will take approximately one year per phase.
  d) Sample Size: Modeling efforts will combine all available data (e.g., benthic sampling, water quality monitoring, sturgeon telemetry) to best inform outputs.

e) Sites: The model will be conducted at a basin-wide scale using information from numerous sites/data throughout Lake Borgne; however, the focus of the outputs would be directed at the area covered by the large-scale cooperative telemetry array.

3 Adaptive Management

Monitoring information collected at the project-level can be used to adaptively manage the project to improve restoration outcomes. Within the LA TIG, an adaptive management framework has been developed that identifies and characterizes the four main phases and is illustrated within a representative management cycle (Figure 2).

1. Goal-Setting Phase: Problem is identified or defined, and project goals and objectives are established based on multiple sources, including lessons learned, data and associated synthesis, and applied research from previous projects and from the knowledge base as a whole. For the Lake Borgne Project, the goal setting phase is already complete – the problem of marsh loss has been defined through the PDARP/PEIS as well as through Louisiana's Coastal Master Plan process, and the goals and objectives of restoration are as described in the restoration plan that accompanies this MAM plan.
2. Design and Construct Phase: Project advances through select steps, including model development or refinement, identification and prioritization of uncertainties, plan formulation, engineering, design, and project construction. For this project, the elements of a preliminary design have already been described within the Restoration Plan, incorporating available data on water depths, intertidal range for nearby marsh, and local subsidence rates. As the project progresses to more advanced phases, the design may be modified as needed to incorporate any new information that could affect the preliminary design.
3. Operate and Monitor Phase: Project's operations, maintenance, and monitoring plans are developed, and project assessment and evaluation criteria are identified. Note that for this and other marsh creation projects, the opportunities for adaptive management post-construction may in some cases be limited. For example, if the marsh platform does not achieve the proper elevation post-settlement, re-mobilizing a dredge to modify the marsh platform elevation is generally cost-prohibitive. However, supplemental vegetative plantings can be used to improve vegetative cover if the marsh platform is already at the proper elevation.
4. Adaptive Management Coordination Phase: Encompasses steps for recommending and approving project revisions so that revisions can achieve one or both of the following:

    - Result in alterations and redesign of project elements or changes to project operation
    - Provide input to either the understanding of the overall problem statements or the refinement of attainable or realistic goals and objectives for future projects

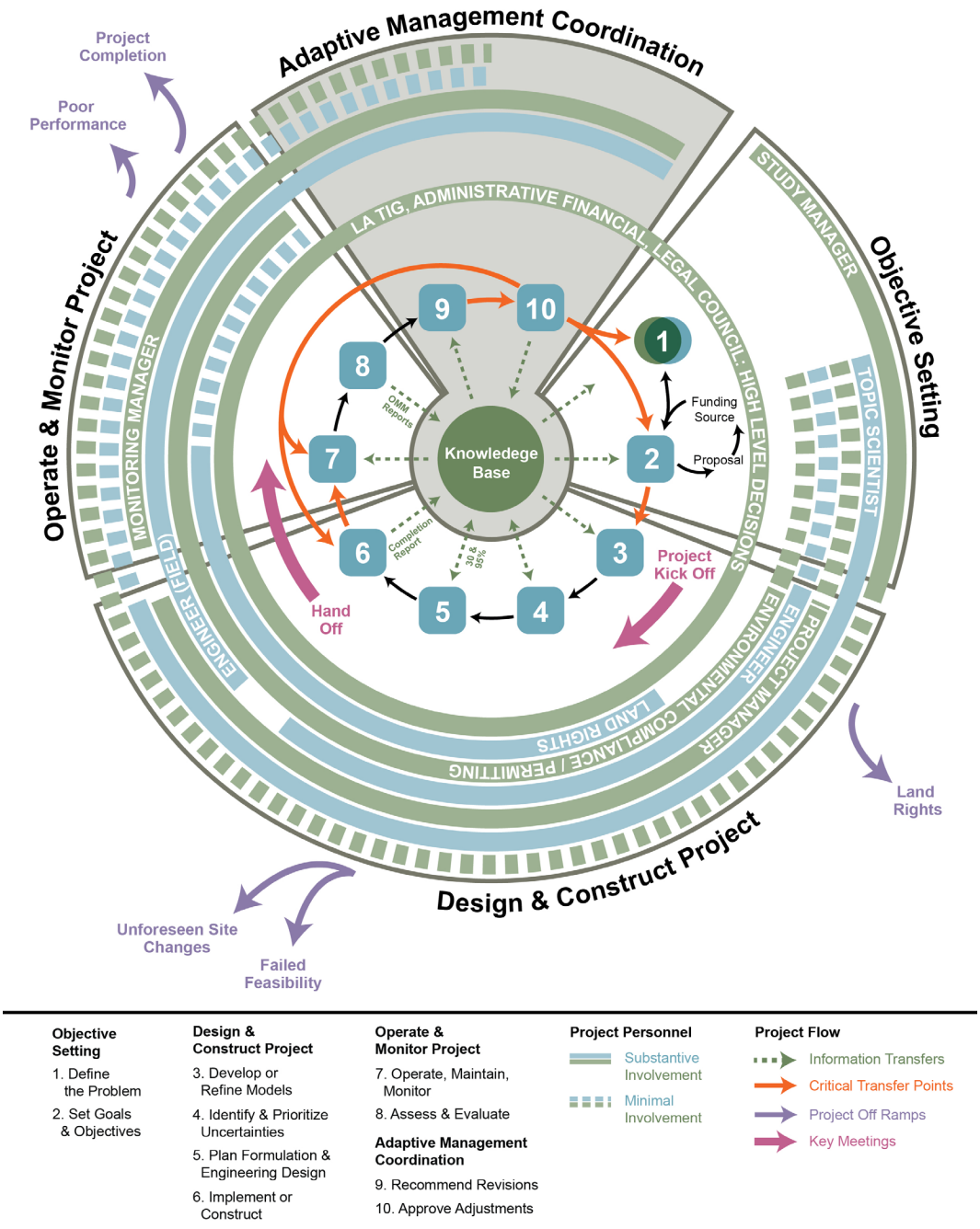

Figure 2. LA TIG Adaptive Management Cycle (Source: The Water Institute of the Gulf. 2019).

4 Evaluation

Evaluation of monitoring data is needed to assess the project implementation and performance in meeting restoration objectives, resolving uncertainties to increase understanding, and determining whether corrective actions are needed.

As part of the larger decision-making context, the evaluation of monitoring data from individual projects could also be compiled and assessed at the restoration type and LA TIG level, and the results would be used to update the knowledge base to inform decisions such as future LA TIG project prioritization and selection, implementation techniques, and the identification of critical uncertainties. Reports, presentations, and/or lesson learned meetings are potential avenues of transferring information to the LATIG and other agency personnel about project performance.

The results of these analyses would be used to answer the following questions and would be included within the reports described in Section 8:

- Were the project restoration objectives achieved? If not, is there a reason why they were not met?
- Did the restoration project produce unanticipated effects?
- Were there unanticipated events unrelated to the restoration project that potentially affected the monitoring results (e.g., hurricanes)?
- Were any of the uncertainties identified prior to project implementation resolved?
- Were any new uncertainties identified?

Proposed analysis methods are grouped below by monitoring parameters:

Parameter #1: Spatial Extent (acres) of marsh creation

Proposed Analysis Method: Aerial imagery, elevation, and/or vegetation data sets collected for the project will be used to determine habitat evolution and acreages. Aerial imagery will be analyzed for land – water composition. Elevation data and vegetation data will be used to determine habitat types and species composition of those habitats.

Parameter #2: Elevation of marsh

Proposed Analysis Method: The project's Final Design Report will establish the desired elevation of each feature in order for appropriate herbaceous species to colonize and create marsh habitat. Data will be analyzed for the average elevation in each habitat. Other mapping products such as triangulated irregular network (TIN) models could be generated in Geographical Information System (GIS) software packages along with digital elevation models (DEM) to show the elevation across the project area. Over time, differences amongst the individual models would show elevation changes.

The constructed target elevations for marsh will be determined using the methodology(ies) in CPRA's Marsh Creation Design Guidelines (2017). These elevations use various data sources such as water elevation, sea-level rise, and subsidence. At YRs 3 and 5, data will be analyzed using the same methods and updated data (current water elevations and habitat elevations) to determine if the habitat is within the optimal marsh inundation ranges for habitat development. The same water level gauges used in the Final Design Report will be used for YRs 3 and 5, if still active.

The average elevation will be determined using YRs 3 and 5 data sets to determine if these elevations are as predicted in the project settlement curves that will be published in the Final Design Report. However, the elevation of marsh is not a performance criterion at years 3 and 5.

Parameter #3: Vegetative Cover

Proposed Analysis Method: General descriptive statistical analyses may include, but are not limited to, averages/means of the overall total cover by herbaceous species and/or shrubs (marsh); percent cover of species; and/or average height of dominant species. After each data collection effort, all collected and analyzed data will be evaluated to determine existing habitat type. After multiple data collection efforts, comparisons between each time period will be assessed to determine the evolution of the habitat. Data from CRMS sites in the vicinity, within the basin, and coast-wide of similar habitats may be analyzed for comparative performance purposes.

Parameter #4: Invasive Species Cover

Proposed Analysis Method: Data sets will be examined for invasive species. If invasive species are identified within the data set, the average percent cover will be calculated.

Parameter #5: Gulf Sturgeon Telemetry

Proposed Analysis Method: The data will be evaluated to determine differential habitat utilization of Lake Borgne by acoustically tagged juvenile and adult Gulf sturgeon, with a specific focus on lower Lake Borgne including the dredge borrow locations for the Golden Triangle and Lake Borgne marsh creation projects. The two-year telemetry monitoring period will span the initiation of dredging activities to allow elucidation of any potential impacts on sturgeon observations. This analysis will be integrated with additional cooperative sturgeon telemetry work providing coverage for the entirety of Lake Borgne, and all data will couple with the environmental modeling analysis described in Parameter #9 to provide an understanding of spatial and temporal habitat utilization by Gulf sturgeon.

Parameter #6: Water Quality

Proposed Analysis Method: The data will be evaluated to understand the nature of change in suitability of the aquatic environment for Gulf sturgeon and the degree to which dredging depth might contribute to differences in water quality which in turn may affect habitat suitability and benthic prey. This parameter will initially be collected in conjunction with benthic sampling and telemetry monitoring to establish a pre-construction baseline and will also monitor potential water quality changes after the initiation of dredging activities. After dredging is completed the water quality monitoring will resume with a focus on the dredge borrow areas, with monthly sampling continuing for at least one year. If stratification and/or hypoxia is observed, the sampling will be increased to every other week and the water quality monitoring efforts may be extended up to five years post-construction based on observational trends. Information gleaned from this parameter can be used to guide future restoration planning efforts through adaptive management.

Parameter #7 Benthic Macroinvertebrate Recolonization

Proposed Analysis Method: Benthic macroinvertebrate communities and substrate grain size and organic content will be sampled and assessed prior to dredging activities to serve as a representative baseline. Over time, these sampling efforts will be repeated immediately after dredging ends, and again at years 1, 3, and 5 post-dredging to estimate the rate and characteristics of benthic community recovery. Sampling in years 3 and 5 would be optional and needed only if recolonization is not observed by year 1. Comparative substrate composition can also be used to determine potential correlation between macroinvertebrate recolonization and physical shifts in substrate over time within the dredge

locations. This parameter will be collected as a pre-construction baseline and will continue post-construction in reference and borrow areas to identify benthic community changes over time.

Parameter #8: Borrow Area – Infilling Rate

Proposed Analysis Method: Single-beam bathymetry data will be analyzed to determine the rate of sediment infilling by averaging the elevation at the time of survey and comparing to previous survey average elevation. The time between surveys will allow a rate to be calculated. Other mapping products such as triangulated irregular network (TIN) models could be generated in Geographical Information System (GIS) software packages along with digital elevation models (DEM)DEMs to show the elevation across the project area. Over time, differences amongst the individual models would show elevation changes as well as volumetric changes.

Parameter #9: Modeling

Proposed Analysis Method: Models will be developed to identify the environmental conditions that are correlated with Gulf sturgeon presence, and habitat suitability, in the Lake Borgne basin. The models will reduce potential overlap with Gulf sturgeon habitat, and therefore improve the site selection process, for future dredging and restoration projects within designated critical habitat for that species. Models will provide the capacity to derive environmental parameters like salinity, temperature, and dissolved oxygen on a daily timescale to match records of Gulf sturgeon occupancy for the area derived from sturgeon telemetry work. Phase 1 of the modeling efforts will include the development of model conditions, and production of components that feed into habitat suitability (environmental and physical conditions) at a basin-wide scale. Phase 2 will overlay past telemetry information into the numerical habitat model developed in the first phase and hind-cast sturgeon movement patterns based on previously collected telemetry data. Phase 3 of modeling will update the model and re-run outputs with the incorporation of new sturgeon telemetry data collection efforts (i.e., Parameter #5), thus allowing for predictive forecasting of sturgeon habitat utilization to inform future projects in the area.

5 Project-Level Decisions: Performance Criteria and Potential Correction Actions

The LA TIG describes how updated knowledge gained from the evaluation of monitoring data will be used at the project-level to determine whether the Project is considered successful or whether corrective actions are needed. A project may not be achieving its intended objectives because of previously identified key uncertainties, unanticipated consequences, previously unknown conditions, or unanticipated environmental drivers. The decision to implement (or not implement) corrective actions is one type of decision within the larger adaptive management decision-making framework.

Learning through monitoring allows for corrective actions to be made to achieve desired outcomes. Table 2 identifies performance criteria, monitoring parameters, and potential corrective actions that could be taken if the performance criteria are not met (as defined in NRDA regulations (15 CFR 990.55(b)(1)(vii)). This table should not be considered all encompassing; rather, it represents a listing of potential actions for each individual parameter to be considered if the project is not performing as expected once implemented. Other corrective actions may be identified post-implementation and included in an operations and maintenance (O&M) plan. The decision of whether or not a corrective action should be implemented for the project should consider the overall outcomes of the restoration project (i.e., looking at the combined evaluation of multiple performance criteria) in order to understand

why project performance deviates from the predicted or anticipated outcome. Corrective action may not be taken in all cases based on such considerations. The knowledge gained from this process could also inform future restoration decisions such as the selection, design, and implementation of similar projects.

Table 2. List of Project Monitoring Parameters, Performance Criteria, and Potential Corrective Actions.

Notes: [1] The land loss rate of 0.62% was determined from the 23,900 acres of marsh that existed in 1932 and 16,600 acres of marsh that existed in 1990, i.e., lost 7,300 acres in 58 years or 125.86 acres/year. Source: Appendix C, Coast 2050: Toward a Sustainable Coastal Louisiana. [2] The project is currently gathering data to make the final determination. The Final Design Report is scheduled for late 2019. [3] As needed, depending on results of each monitoring period.

Monitoring Parameter	Final Performance Criteria Used to Determine Project Success	Potential Corrective Actions
Spatial Extent	There will be no more than the equivalent of 0.62% annual land loss rate between year 0 and 5 post-construction. (See note 1 above this table)	Planting of appropriate species
Elevation	The target elevations stated in the Final Design Report at the time of construction. (See note 2 above this table)	Addition or regrading of sediments
Vegetative Cover	Live vegetative cover is equal to or greater than 65% at Year 5	Planting of herbaceous species
Invasive Species Cover	Average live vegetative cover of invasive species is not greater than 25% at Year 5.	Mechanical removal or herbicide application
Gulf Sturgeon Telemetry	Successfully deploy an acoustic receiver array, prior to and continuing until after the initiation of dredging activities, to detect the presence of acoustically tagged Gulf sturgeon throughout Lake Borgne.	If relatively high numbers of detections occur in the project area, appropriately refocus the scope of monitoring and analysis.
Water Quality (See note 3 after this table)	The successful monitoring of water quality parameters prior to and after dredging activities, and identification of differential trends by dredge depths.	Adaptively manage future projects in the area to take into account information gleaned from dredge depths on water quality
Benthic Macroinvertebrate Recolonization (See note 3 above this table)	Collection of surficial grab samples for the analysis of substrate grain size and benthic invertebrate communities in the project area and quantify recolonization rates.	Extend sampling duration should areas remain un-colonized after year 5
Borrow Area – Infilling Rate	Collection of single beam bathymetry data within and around the borrow area	Inform future dredging projects about depths that reduce impacts on benthos and refill rate

Monitoring Parameter	Final Performance Criteria Used to Determine Project Success	Potential Corrective Actions
Modeling	Completion of all three phases of modeling outputs, including habitat and sturgeon telemetry hindcast and forecast.	Provide results and model to inform future restoration projects

6 Monitoring Schedule

The project monitoring schedule (Table 3) is separated by monitoring activities. Pre-execution monitoring will occur before any project construction activities occur, if applicable. Execution of monitoring will occur when the construction activities have been deemed complete. Performance monitoring will occur in the years following construction (YRs 0-5).

Table 3. Monitoring Schedule (Pre-Execution, As-Built and Ongoing).
Notes: "X" indicates required data acquisitions; "O" indicates optional data acquisition; "n/a" indicates not applicable. [1] Modeling will be conducted in three phases each lasting approximately one year. The third phase involves the incorporation of data collected through sturgeon telemetry efforts (i.e., Parameter #5), and is not necessarily correlated with the post-execution monitoring schedule/timeline.

Monitoring Parameters	Pre-Execution Monitoring Year -1	Execution Monitoring (initial) As-built (Year 0)	Ongoing Execution Year 1	Ongoing Execution Year 2	Ongoing Execution Year 3	Ongoing Execution Year 4	Ongoing Execution Year 5
Vegetation Survey	n/a	n/a	X	n/a	X	n/a	X
Elevation Survey	n/a	X	n/a	n/a	X	n/a	X
Aerial Imagery Acquisition	X	X	O	O	X	O	X
Gulf Sturgeon Telemetry	X	X	O	O	O	O	O
Water Quality	X	X	X	O	O	O	O
Benthic Macroinvertebrate Recolonization	X	X	X	n/a	O	n/a	O
Borrow Area – Infilling Rate	n/a	n/a	X	n/a	X	n/a	X
Modeling (See note 1 above this table)	X	X	X	n/a	n/a	n/a	n/a

7 Data Management

7.1 Data Description

To the extent practicable, all environmental and biological data generated during monitoring activities will be documented using standardized field datasheets. If standardized datasheets are unavailable or not readily amendable to record project-specific data, then project-specific datasheets will be drafted prior to conducting any project monitoring activities. Original hard copy datasheets and notebooks and photographs will be retained by the implementing Trustee.

Relevant project data that are handwritten on hard copy datasheets or notebooks will be transcribed (entered) into standard digital format. All field datasheets and notebook entries will be scanned to PDF files. Electronic data files should be named with the date on which the file was created and should include a ReadMe file that describes when the file was created and by whom and any explanatory notes on the file contents. If a data file is revised, a new copy should be made and the original preserved.

All data will have properly documented FGDC/ISO metadata, a data dictionary (defines codes and fields used in the dataset), and/or a ReadMe file as appropriate (e.g., how data were collected, quality assurance/quality control [QA/QC] procedures, and other information about data such as meaning, relationships to other data, origin, usage, and format—can reference different documents).

7.2 Data Review and Clearance

Data will be reviewed for QA/QC in accordance with the *Monitoring and Adaptive Management Procedures and Guidelines Manual Version 1.0* (*Deepwater Horizon* (DWH) Natural Resource Damage Assessment Trustees. 2017), and any errors in transcription will be corrected. Implementing Trustees will verify and validate data and information and will ensure that all data are entered or converted into agreed upon/commonly used digital format and labeled with metadata following FGDC/ISO standards to the extent practicable and in accordance with implementing Trustee agency requirements.

After all identified errors are addressed, data are considered to be cleared. The implementing Trustee will give the other LA TIG members time to review the data before making such information publicly available (as described below). Before submitting the monitoring data and information package, co-implementing Trustees shall confirm with one another that the package is approved for submission.

7.3 Data Storage and Accessibility

Once data have been cleared, they will be submitted to the Restoration Portal.

Trustees will provide DWH NRDA MAM data and information to the Restoration Portal as soon as possible and no more than 1 year from when data are collected.

7.4 Data Sharing

Data will be made publicly available in accordance with the Federal Open Data Policy through the DIVER Explorer Interface within 1 year of when the data collection occurred. Also, data will be made available through the Coastal Protection and Restoration Authority's Coastal Information Management System (CIMS) database, which can be accessed at the following link: https://cims.coastal.louisiana.gov/default.aspx. Larger datasets such as LiDAR will be made available through portals appropriate for handling the associated file sizes.

8 Reporting

Based on the project monitoring schedule (Section 6), associated reporting will be submitted in post-construction YRs 2, 4, and 6 which represents one year after data collection efforts in YRs 1, 3, and 5. Each of these reports will primarily focus on answering the questions presented in Section 4, Evaluation. The YR 1 and 3 reports will be more progress related reports, whereas the YR 5 report will be comprehensive in nature and answer whether or not the project met each of the performance criteria

(PC). If the project did not meet a PC, then an explanation will be provided. For each report, if corrective actions are required then a corrective action plan would be generated, and variables would continue to be monitored. There will also be additional reports developed for initial monitoring efforts to describe baseline conditions measured pre-construction (Parameters #5 and #6), and to also report the results from the telemetry and modeling efforts (Parameters #4 and #9).

The reports will follow the template recommended in the *Monitoring and Adaptive Management Procedures and Guidelines Manual Version 1.0* (*Deepwater Horizon* (DWH) Natural Resource Damage Assessment Trustees. 2017), Appendix D. MAM reports and lessons learned from the monitoring activities will be disseminated to the LA TIG through relevant portals, and information will be more broadly disseminated at conferences to reach a larger audience.

9 Roles and Responsibilities

The LA TIG is responsible for addressing MAM objectives that pertain to their restoration activities and for communicating information to the Trustee Council or Cross-LA TIG MAM work group. CPRA is the implementing Trustee for the project. The U.S. Department of the Interior will be the lead federal agency for conducting the environmental evaluation review for implementation. The implementing Trustees' roles include:

- Data collection
- Data analysis
- Report composition
- Ensuring corrective action activities are performed, if necessary
- Providing project progress information to the LA TIG

10 Monitoring and Adaptive Management Budget

The overall budget for the project monitoring and adaptive management plan is $3,000,000 and covers the activities identified in Table 3 as well as data analysis, report composition, and project management. This budget may be reduced if telemetry results indicate that dissolved oxygen and/or benthic invertebrate sampling is no longer needed post-construction.

11 References

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12 MAM Plan Revision History

Table 4. MAM Plan Revision History.

Old Version #	Revision Date	Changes Made	Reason for Change	New Version #
N/A	N/A	N/A	N/A	N/A