River Reintroduction into Maurepas Swamp Project (PO-0029)
Preliminary Operations, Maintenance, Monitoring, and Adaptive Management Plan

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

1D	One-dimensional
2D	Two-dimensional
ADCIRC	Advanced Circulation Model
ADCP	Acoustic Doppler current profiler
AREMA	American Railway Engineering and Maintenance-of-Way Association
C	Carbon
CEMVN	United States Army Corps of Engineers, New Orleans District
cfs	Cubic feet per second
chl a	Chlorophyll a
CIMS	Coastal Information Management System
CIR	Color infrared
CN RR	Canadian National Railroad
CPRA	Coastal Protection and Restoration Authority
CRMS	Coast-wide Reference Monitoring System
CWPPRA	Coastal Wetlands Planning, Protection, and Restoration Act
DBH	Diameter at breast height
DO	Dissolved oxygen
EPA	United States Environmental Protection Agency

GEBF	Gulf Environmental Benefit Fund
HEC-RAS	Hydrologic Engineering Center-River Analysis System
I-10	Interstate 10
KCS RR	Kansas City Southern Railroad
LA 44	River Road
LDNR	Louisiana Department of Natural Resources
LDOTD	Louisiana Department of Transportation and Development
LDEQ	Louisiana Department of Environmental Quality
LDWF	Louisiana Department of Wildlife and Fisheries
MRGO	Mississippi River Gulf Outlet
NFWF	National Fish and Wildlife Foundation
NH_4^+	Ammonium
NO_3^-	Nitrate
OCM	Louisiana Department of Natural Resources, Office of Coastal Management
OMMAM	Operations, Maintenance, Monitoring, and Adaptive Management
PM	Performance measure
PO_4^{-3}	Phosphate
RESTORE Act	Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act
RSET	Rod surface elevation table
SCADA	Supervisory control and data acquisition
SiO_4 -	Silicate
SLR	Sea level rise
SWAMP	System-wide Assessment and Monitoring Program
SWMM	Stormwater Management Model
TAG	Technical Advisory Group
TN	Total nitrogen
TP	Total phosphorous
TSS	Total suspended solids
US 61	Airline Highway
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WMA	Wildlife Management Area
WSLP	West Shore Lake Pontchartrain Project

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INTRODUCTION

This preliminary Operations, Maintenance, Monitoring, and Adaptive Management (OMMAM) plan was written by the Coastal Protection and Restoration Authority (CPRA) of Louisiana staff in the Executive, Planning and Research, Engineering, Operations, and Project Management divisions to inform the implementation and adaptive management of the Mississippi River Reintroduction into Maurepas Swamp (PO-0029) Project. This project will introduce Mississippi River water into the southern portion of the Maurepas Swamp via a gated intake structure at the river levee and a conveyance channel into the project area, with additional outfall features designed to help distribute the flow throughout the project area to reduce or minimize future loss of coastal forest habitat. CPRA engineers and ecologists provided input to the plan and utilized the extensive body of work (see Appendix B) that has been conducted over the last couple of decades during project development. In addition, we relied on the existing framework of the System-wide Assessment and Monitoring Program (SWAMP) and its wetland component, the Coast-wide Reference Monitoring System (CRMS). CPRA's established standard operating procedures and protocols for the protection and restoration program have informed this OMMAM plan as well. The goal of this preliminary plan is to describe key features of the project along with management of their operations, maintenance, and monitoring. Additionally we contracted a Technical Advisory Group (TAG) of forest ecologists to provide general operational plan guidance for project success and identify key monitoring elements to assess success of the project as it relates to its goals and objectives (Krauss et al. 2017). A more detailed operational plan will be developed based on information obtained from the new Delft 3D model outputs and input from the TAG, among other sources.

The CPRA has long recognized the importance of adaptive management as it relates to Louisiana's coastal program. Because both natural and socio-economic systems are inherently uncertain, it is difficult to predict future effects of restoration actions with complete certainty. As both the coastal landscape and CPRA have changed over the years, CPRA has spent an increasing amount of time on adaptive management efforts. Adaptive management, as CPRA defines it, is a structured process for making decisions over time through active learning that enables adjustments to be made in projects and programs as new information becomes available (Raynie 2017). It embraces a scientific approach that involves identifying goals and objectives, developing and implementing actions, assessing the system's response to the actions, and utilizing that knowledge to make management decisions. It also recognizes the importance of stakeholder engagement and consensus building when implementing actions that affect structural, ecological, and socio-economic systems. Adaptive management is especially critical with this project because it is CPRA's first Mississippi River reintroduction into a swamp ecosystem and as such, does not have a well-established boiler plate or text book template to follow. An adaptive management approach helps identify realistic outcomes that can be expected from project implementation.

In addition to CPRA's recognition of the importance of adaptive management, other programs operating in Louisiana's coast are including adaptive management in their implementation. Currently, CPRA is utilizing funding from the Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States (RESTORE) Act to fund the River Reintroduction into Maurepas Swamp Project engineering and design. In the RESTORE Act Comprehensive Plan Update in August 2016, adaptive management was highlighted as a priority and was funded at $700 million. RESTORE-funded projects are now required to have an adaptive management plan.

This plan will assist in guiding the design, construction, and operation of the River Reintroduction into Maurepas Swamp Project (hereafter referred to as "the project") throughout its project life. As is consistent with the principles of adaptive management, this plan will be a living document that can be modified during project implementation as conditions warrant.

The area influenced by the project is an approximately 45,000-acre portion of the Maurepas Swamp, located in St. John the Baptist, St. James, and Ascension parishes. It is situated roughly between the southern shore of Lake Maurepas to the north, Blind River to the west, the Reserve Relief Canal to the east, and the developed uplands of the Mississippi River natural levee to the south (Figure 1). The Maurepas Swamp is the second largest contiguous area of forested coastal wetland in Louisiana and one of the largest along the Gulf Coast, encompassing approximately 140,850 acres of baldcypress/water tupelo swamp habitat. Other projects have been proposed and/or implemented to rehabilitate some areas of the swamp beyond the influence of this project with significant areas of similarly stressed and shifting habitats.

The Maurepas Swamp, including the waterways and the adjacent shoreline areas of Lake Maurepas, provides significant and increasingly scarce habitat in the region for many species such as birds, alligators, deer, rabbits, raccoons, turtles, fish, crabs, shrimp, and the occasional manatee. The National Audubon Society has designated the Maurepas Swamp as an Important Bird Area, providing significant habitat for many year-round avian residents as well as species whose migration routes stretch throughout North and South America.

Maurepas Swamp also provides numerous ecosystem services to the communities in and around the swamp and beyond. Much of the swamp is state-owned and accessible to the public for hunting, fishing, and other recreational activities in three Wildlife Management Areas (WMAs) managed by the Louisiana Department of Wildlife and Fisheries (LDWF), with much of the project area and other WMA acreage acquired through CPRA's Coastal Forest Conservation Initiative. The Tickfaw State Park, managed by the Louisiana Office of State Parks, provides cabins, camping, educational, and recreational facilities. Southeastern Louisiana University's Turtle Cove Environmental Research Station provides a significant base for research, education, and outreach. Bayou Manchac and Blind River are Louisiana Historic or Natural and Scenic Streams, respectively, and along with the many other rivers and streams in the area are heavily utilized for water-based recreational activities.

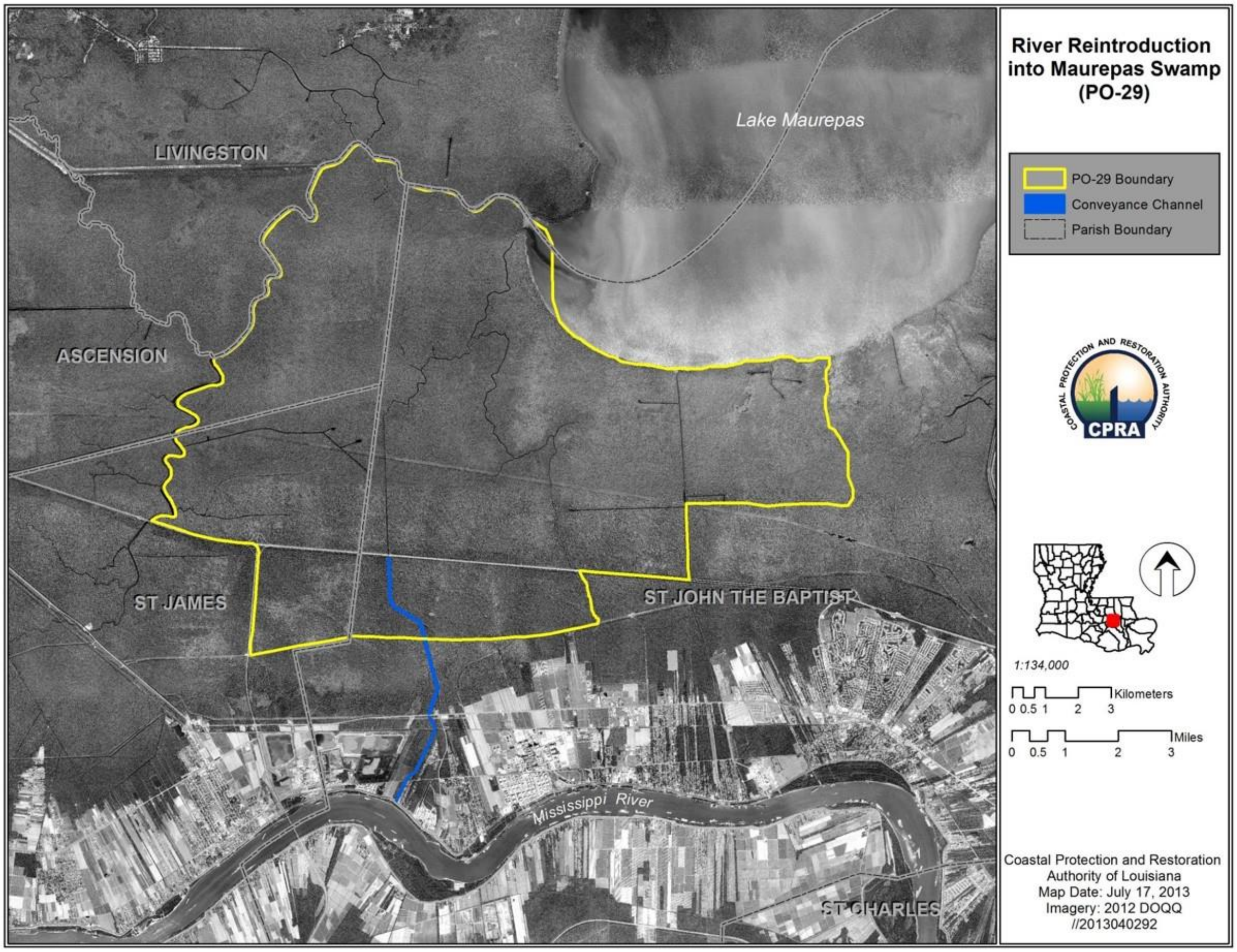

Figure 1. Map depicting project influence area and conveyance channel.

As an alternative to traversing the distance from the Mississippi River's mouth in the Gulf of Mexico to the upper parts of the Mississippi River, the route via lakes Pontchartrain and Maurepas, the Amite River, and Bayou Manchac was a significant trade route for Native Americans and later European settlers, also forming the international boundary during various historic periods. The Manchac Greenway on U.S. Highway 51 on the landbridge between lakes Pontchartrain and Maurepas provides cyclists and others access and views of the swamp at ground level while Interstate 55 traverses the same area at a higher elevation. Numerous cultural resources such as cemeteries, Native American mounds, and other historic sites exist in the swamp, and ecotourism via swamp tours is enjoyed by many visitors from outside the area.

There are still residents of the area who maintain traditional ecological knowledge and cultural ties to the swamp through harvest of various species for sustenance and income.

The communities surrounding Maurepas Swamp are some of the fastest growing areas of the state. These communities, and the significant industrial development along the Mississippi River, currently have no significant structural hurricane protection. Swamp forests provide amelioration of tropical storm effects as well as floodwater storage from rainfall events. The trees help ameliorate air pollution and also provide carbon sequestration, with both ecosystem services increasing with increased forest productivity. Forested wetlands also improve water quality. Many of the area streams are designated by the Louisiana Department of Environmental Quality (LDEQ) as Outstanding Natural Resource Waters that are also considered impaired for several parameters and uses.

There are many ecological problems in this area, but possibly the most significant is the current hydrologic regime, which is no longer conducive to sustain swamp forest habitat (Shaffer et al. 2009, 2016). Historically, the swamp received oxygenated water, sediment, and nutrient inputs from the Mississippi River during seasonal overbank flooding and via Bayou Manchac. That process was interrupted by the construction of local levees along the Mississippi River since early colonization for flood control as well as the blockage of the connection with Bayou Manchac in the War of 1812, which was made permanent in 1828. Federal control of the Mississippi River levee system by the U.S. Army Corps of Engineers (USACE) after the Great Flood of 1927 prevented any further natural connection of the swamp to the river's life-sustaining waters. Reduced flow of fresh water through the swamp has created oxygen-poor, stagnant water conditions that impair forest health and associated aquatic habitats. By contrast, the swamp forests within the Bonnet Carré spillway, which receive significant levels of fresh water and associated sediments and nutrients from the Mississippi River when the flood control structure is opened, are much healthier than those outside of its direct influence (Day et al. 2012.

In addition to the disconnection from the Mississippi River, the swamp's hydrology issues have been exacerbated by the construction of highways, pipelines, railroads (including abandoned logging railroads), pull boat canals (also associated with logging), the Amite River Diversion Canal, navigation canals, and oil and gas exploration canals, along with the spoil banks associated with canal excavation. The channelization of local streams and the construction of local flood mitigation features such as weirs, local levees, floodgates, and drainage ditches have also altered hydrology in the area. This altered hydrologic regime, especially the reduced freshwater inflow and outflow, has resulted in periodic introduction of brackish water from Lake Pontchartrain into Lake Maurepas and the swamp (Shaffer et al. 2009, 2016). This introduction was exacerbated by the construction of the Mississippi River Gulf Outlet (MRGO) that created a saltwater and storm surge conduit from the Gulf of Mexico south of New Orleans, through Lake Pontchartrain, and into the Maurepas Swamp. The MRGO was closed in 2009 and some salinity reductions have been noted, but droughts, sea level rise, and storm surge still cause periodic high salinities. Because the swamp is dominated by baldcypress and water tupelo, each having a relatively low tolerance to salinity, saltwater intrusion can be fatal. Impounding features, coupled with low soil surface elevations, have exacerbated saltwater intrusion by trapping saltwater from storm surge in the swamp, resulting in the mortality or degradation of many trees in those areas near Lake Maurepas (Shaffer et al. 2016).

The isolation of the swamp from the Mississippi River has also resulted in the deprivation of nutrients and sediments which are important for forest health, structure, function, and resilience. Nutrients and sediments promote vertical accretion and help maintain wetland surface elevation on pace with relative sea level rise. Only those areas adjacent to streams transporting local upland runoff are receiving nutrients and sediment along with flowing water that helps sustain those forests (Shaffer et al. 2009, 2016). The forests on the edges of these waterways are healthier than those of the interior swamps, demonstrating the need for periodic inundation of the whole system with river water as sheet flow.

The near permanent flooding of much of the area prevents germination of baldcypress and water tupelo seeds, which coupled with nutria herbivory of seedlings has greatly reduced natural regeneration of the forest. Because the majority of the old growth swamp trees were clear-cut in the late 1800s and early 1900s, most of the current trees have spent their entire lives in these degraded conditions. The harvest of second-growth trees continued to utilize non-sustainable forestry practices (Chambers et al. 2005) until harvesting was limited by conservation acquisitions and the regulatory recognition that harvesting coastal wetland forests largely resulted in conversion to non-forested habitats. These factors, in addition to conversion of forests to urban, suburban, industrial, and agricultural land, have contributed to an overall reduction in coastal forest area and reduced health, structural integrity, and resilience of what remains.

The combination of these factors has resulted in significant swamp habitat loss, with the degraded swamp in some areas converting to freshwater marsh habitat and open water. Although much of the past damage to the swamp cannot be undone and the old growth forest will not be restored, many scientists believe it is still possible to rehabilitate and prolong the existence of what forest remains through restoration of the processes that sustain its functions, structure, and resiliency.

PROJECT GOALS AND OBJECTIVES

The goal of the project is to reduce or minimize future loss of coastal forest habitat in the project area through the introduction of Mississippi River water. The project is needed to convey fresh water, nutrients, and sediments to restore the health and essential functions of the swamp. The project area of influence is approximately 45,000 acres, including closed forest canopy, transitional forest, and degraded forest (open canopy/marsh) habitat types or condition classes.

The objectives of the Mississippi River Reintroduction into Maurepas Swamp are to establish a hydrologic regime consistent with swamp forest sustainability that will introduce flowing oxygenated water; ameliorate salinity intrusion; facilitate nutrient uptake and retention; increase forest health and structural integrity; and increase rates of soil surface elevation gain to offset subsidence. If these objectives are achieved, swamp habitat structure, function, and resilience will increase, and conversion to non-forested habitats will be reduced. Further details on operational considerations of the diversion structure and associated outfall management, recommended performance measures, the draft monitoring plan, and adaptive management of the project are discussed in subsequent sections.

PROJECT CONSTRAINTS AND UNCERTAINTIES

Design constraints include accommodating existing man-made as well as natural hydrologic features and maintaining effective drainage throughout the project area. There are engineering and site- or project-specific constraints associated with each project design feature. Operational constraints are primarily dictated by the river stage at any particular point in time and the maximum volume of water that can be flowed through the sluice-gated structure and conveyance channel. This design was constrained by the volume that could be safely conveyed through the existing Hope Canal channel under the Interstate 10 (I-10) bridge without altering the structure. The operation of the diversion can reduce or shut off the volume of diverted flow based on variable operation of the sluice gates. The operation of the diversion will attempt to provide the seasonal and inter-annual variability of flows associated with restoring the health and function of the swamp as described in the operations section below, but is constrained by the current conditions of the swamp, limits of the diversion's influence area and other hydrologic factors.

Uncertainties that have been considered in developing this project and its OMMAM Plan include future sea level rise rates, weather events (such as droughts, rainfall, local riverine floods, and tropical events) variability in timing and volume of river flow, interaction with new flood protection features such as the future USACE West Shore Lake Pontchartrain (WSLP) Project, and other local drainage and protection projects. Additional uncertainties include future development in the watershed and associated hydrologic changes that may occur.

CPRA recognizes that the diversion will not affect the entire project area identically due to its large size, topographic variability and location-specific levels of swamp degradation. In addition, the attainment of specific target values for performance measures will vary with respect to time and will require an appropriate data collection frequency and duration to detect a measureable response from the diversion. Due to these complexities and uncertainties that have arisen from this being the first river reintroduction project targeting a coastal swamp in Louisiana, CPRA worked with the TAG to develop performance measures for key attributes of forested wetland ecosystem functioning, including hydrology, salinity, nutrients, accretion, and vegetation (Krauss et al. 2017). To develop the performance measures, the TAG identified previously existing data, summarized those data, investigated reference locations, and recommended target values relevant for Louisiana coastal swamp forests. The TAG has identified specific target values for each performance measure and has provided monitoring guidelines for this project. If the targets are reached, at least in some areas of the swamp, it is expected that the project is providing habitat conditions that will help sustain the swamp forest for decades longer than without project implementation.

PROJECT HISTORY

This project has received funding from a variety of sources - including the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA), Louisiana State-only surplus funds, the Gulf Environmental Benefit Fund (GEBF) via the National Fish and Wildlife Foundation (NFWF), and RESTORE Act—over the last 25 years for planning, engineering, and design. Plans to reintroduce Mississippi River water in the vicinity of Maurepas Swamp have existed since 1993. Studies were performed during a pre-"CWPPRA Phase 0" effort, then CWPPRA Phase 0. The Mississippi River Reintroduction into Maurepas Swamp (PO-29) received its Phase I (engineering and design) funding through the CWPPRA in 2001. Region 6 of the Environmental Protection Agency (EPA) was the lead federal agency with Louisiana Department of Natural Resources (later CPRA) serving as the non-Federal sponsor. See Appendix B for a list of prior studies and reports.

CPRA submitted a Joint Permit Application to the Louisiana Department of Natural Resources (LDNR) Office of Coastal Management (OCM) in May 2013; OCM transmitted the permit application to USACE New Orleans District (CEMVN) in June 2013; CEMVN published the public notice on the permit application in August 2013; and CEMVN transmitted all received comments to CPRA in October 2013. The United States Fish and Wildlife Service (USFWS), in their comments, requested hydrologic modeling to address future–with-project and future-without-project salinity conditions and a monitoring and adaptive management plan for review.

As 95% project design was nearing completion in May 2014, the project costs for implementation were too large for traditional CWPPRA funding. Therefore, CPRA began using State-only surplus and NFWF funds to maintain project momentum. Activities included: finalizing 95% design, continuing work on permitting; performing a review of the existing hydrodynamic modeling; seeking expert advice by creating the Maurepas TAG to assist with the development of PMs; engaging stakeholders including Ascension, St. John the Baptist, and St. James parishes; coordinating with industry in the project area, including Pin Oak Terminals; coordinating with USACE to minimize conflicts with the WSLP Project; and assessing any potential industrial impacts to the project.

In April 2015, CPRA administratively withdrew the permit application due to a lack of funds for permit support (including updated hydrologic modeling), development of an OMMAM plan, and a Section 214 agreement for CEMVN Section 408 review. USACE Regulatory allows an applicant, by request, to reopen processing of an administratively withdrawn permit application with the submittal of previously requested relevant information. For this project, new information would consist of a hydrodynamic modeling report and a draft OMMAM plan.

In a letter from Governor John Bel Edwards to President Trump on March 8, 2017, Governor Edwards identified the River Reintroduction to Maurepas Swamp project as a high priority project in accordance with Trump's Executive Order 13766 "expediting environmental reviews and approval for high priority infrastructure projects." In September 2017, CPRA received RESTORE funds to complete outstanding tasks required to make the project ready for construction. These tasks include creating a new hydrodynamic and water quality model, continuation of engagement with the TAG, continuation of permitting and environmental compliance processes and creating this OMMAM plan, final design, and landrights.

PROJECT NUMERICAL MODELING

In 2007, as part of the Engineering and Design Phase of the project, URS (now AECOM) developed two numerical models that were used in the feasibility and preliminary design of the project. These numerical models included a one-dimensional (1D) drainage model, EPA's Stormwater Management Model (SWMM) and a two-dimensional (2D) hydrodynamic model – the Advanced Circulation (ADCIRC) Model. The SWMM was used to both verify Hydrologic Engineering Center-River Analysis System (HEC-RAS) model results of conveyance channel parameters from the CWPPRA Phase 1 efforts and determine the 250 cubic feet per second (cfs) capacity of the pump station required to maintain the current drainage characteristics post-construction. The pump station is now envisioned to be built as part of the USACE WSLP Project. The ADCIRC model was employed to study the behavior of 2000 cfs of fresh water within the Maurepas Swamp watershed. Preliminary results of the ADCIRC model guided design of small water control features within the watershed to improve freshwater retention and circulation.

Over the past 11 years there have been large advances in computing and model capabilities, therefore a new modeling effort was initiated in 2018. The purpose of the 2018 numerical modeling effort is to support the hydraulic design of the proposed diversion and evaluate the effect of reintroducing fresh water from the Mississippi River on the water levels, velocity, and nutrient distribution throughout the Maurepas Swamp. A 2D hydrodynamic model, Delft3D modeling software (Deltares 2014) will be utilized to evaluate existing conditions and potential operational regimes to facilitate distribution of the introduced fresh water throughout the swamp. Delft3D can simulate water level and velocities throughout the modeled study area. To address the water quality processes, Delft3D can also model nutrients, sediment, dissolved oxygen, and organic matter among other parameters.

PROJECT DESCRIPTION

The project consists of several features that work together to help achieve project goals and objectives. The order of discussion of the features will begin at the Mississippi River and move north into the targeted project influence area. The project features are divided into headworks features, conveyance corridor features, and outfall management features. See Figure 2 for more details.

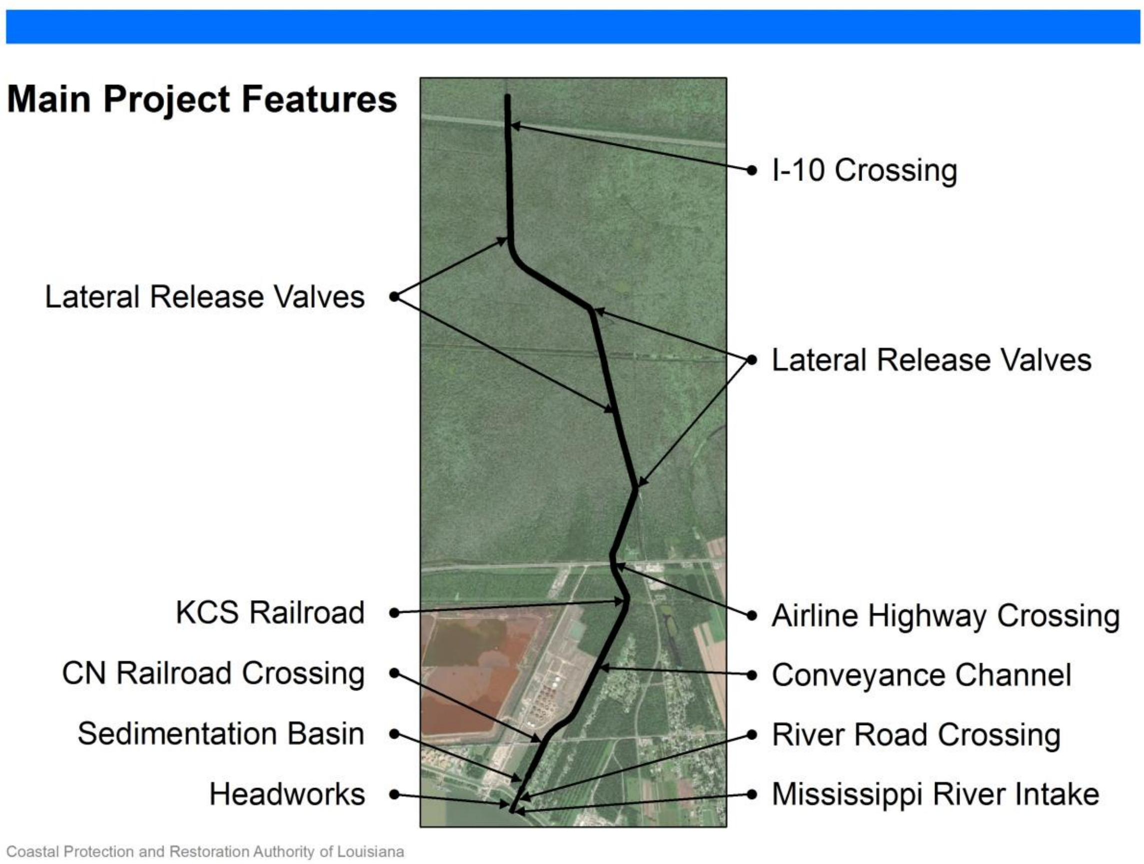

Figure 2. Main project features

Headworks Features

The project's headworks include the intake features in the Mississippi River, a gated structure on the river side (batture) of the Mississippi River levee, with discharge culverts underneath the levee and River Road (LA 44) connecting to a sedimentation basin. The project intake will be located on the river side of the Mississippi River levee at River Mile 144.2 near Garyville, LA in St. John the Baptist Parish.

A rip-rap lined intake channel will be excavated and constructed in the batture area. Concrete U-channels will tie the intake channel to the intake structure. The intake structure will be comprised of three 10-ft x 10-ft cast iron vertical sluice gates, which will be hydraulically actuated to control the flow of water into the diversion channel. The gates will be of the flat-back type, mounted on a wall thimble, which is integrally cast into the concrete structure. The hydraulic actuators will be mounted on structural steel members that are a part of the intake structure; therefore the gates will not require yokes as a part of the frame and guide rails. The gates will be of a flush-bottom design, eliminating any channel or sill at the base that might inhibit flow or catch debris. The gates will be sealed in the closed position by the action of a series of wedges at the perimeter of the gate frame. The downward force of the actuator and the weight of the gate will drive the gate slide into the wedges which will in turn force the slide into seat facings around the frame periphery. The sluice gates will use a conventional gate system that has been designed to flow at a maximum of 2,000 cfs. The gates will connect to three 10-ft x 10-ft box culverts that will be installed to convey river water under the levee and LA 44.

A headworks building will be constructed to contain the control room and associated supervisory control and data acquisition (SCADA) system and other ancillary features. The SCADA system will be used to both automatically record the operation of the various headworks components and to control their operation remotely. Monitoring equipment (flow detection devices and water quality parameter probes, etc.) will be installed to collect requisite data deemed necessary to successfully operate the diversion.

Beyond LA 44, the culverts transition from a concrete U-channel into a large earthen sedimentation basin. Because this is a freshwater (not sediment) diversion, the project is not intended to deliver coarse sediments from the Mississippi River, only the nutrients and finer suspended particles contained in the freshwater stream. The basin is designed to remove large sediment particles entrained in the diverted Mississippi River flowstream and prevent clogging of the conveyance channel. The basin has sufficient volume to store approximately six months of sediment prior to cleaning without impacting the system's hydraulic performance. Sediment excavation and removal intervals will be adjusted based on actual sediment accumulation. The sedimentation basin discharges over an outflow weir into the conveyance channel.

There will be levee and headworks access roads constructed to ensure continuous access to the headworks facilities. Access roads will also be constructed to access the sedimentation basin for monitoring, maintenance, and periodic sediment removal.

Conveyance Corridor Features

The sedimentation basin will be connected to the 5.5-mile-long earthen conveyance channel, which will re-introduce flow from the river into the Maurepas Swamp. A new channel will be excavated to a point just north of Airline Highway (US 61). Box culverts will be installed to cross under the Canadian National Railroad (CN RR), a bridge will be constructed over the

Kansas City Southern Railroad (KCS RR), and box culverts will be installed to cross under US 61. Just north of US 61, an improved channel will follow the existing Hope Canal alignment to ultimately distribute the diverted water into the forested wetlands 1,000 feet north of I-10. The channel will connect on either side of I-10 to the existing revetment-lined channel under I-10 at Hope Canal. No modification will be made to the I-10 bridge structure. Crown roadways will be built and maintained atop the guide levees along the length of the conveyance channel to provide access for monitoring and maintenance of the channel features.

The USACE WSLP Project will include a pump station at the confluence of the Hope and Bourgeois canals to maintain existing stormwater drainage capacity from the vicinity of the Garyville community. The diversion operations will be coordinated with the operation of the pump station. From the intake structure to just north of US 61, the Maurepas Project and the WSLP Project will co-exist within the same footprint (Figure 3). The Maurepas Project will exist on the west (flood side) of the WSLP Project, and the eastern guide levee of the Maurepas Project will be incorporated into the WSLP levee.

Outfall Management Features

Numerous outfall management features will be constructed to improve retention and circulation of river water within the Maurepas Swamp. The design includes lateral relief valves to be constructed off the water conveyance channel, north of the proposed pumping station and south of I-10, each having pipes with knife gate valves to divert 125 cfs water to the west and east of the constructed channel into the swamp system. One-way check valves will be installed along the north side of I-10 on all culverts underneath I-10 from LA 641 to the Mississippi Bayou overpass. Weirs will be constructed in Bourgeois Canal and Bayou Secret at their intersections with Blind River. Cuts will be created in the abandoned railroad embankment north of I-10 and east of Blind River.

OPERATIONS

After the project is constructed, some of the project features will need to be actively operated to meet project goals and objectives. Features that will be actively operated by CPRA or its designee include sluice gates (with associated SCADA system) and monitoring equipment in the headworks features, and manual discharge valves in the outfall management features. The operation of those features will be discussed in this section and in Appendix A. All other project features are assumed to be passively operated.

Headworks Features

The sluice gates will be hydraulically operated with actuators that can be operated manually on an as-needed basis, but primarily autonomously via the SCADA system which allows remote operations. The headworks SCADA system will be inter-connected with that of the Pin Oak Terminals' leak detection and shutdown system. This will ensure that any potential leaks can be detected and that the system can be shut down quickly to eliminate the transport of any potential spill in the Mississippi River into the conveyance channel. Monitoring equipment, such as flow detection devices and water quality parameter probes will be operated automatically to collect necessary data to adaptively manage the diversion operations. These data may be retrieved remotely or in person.

With a designed maximum operational flow of 2000 cfs, this freshwater diversion is relatively small in comparison to other diversions currently in operation or being proposed for the state.

Despite the small scale, considerable effort has been made to determine appropriate performance measures. Five performance measures have been developed for the project, as outlined in the report by Krauss et al. (2017). While attainment of each PM will influence operations of the diversion, the first performance measure —establishing a hydrologic regime consistent with swamp forest sustainability—will be the most critical to daily diversion operations.

The diversion will be operated to facilitate the intermittent flow of river water over the surface of the swamp. Having periods of throughput will allow for the delivery of vital nutrients and fine sediments into the swamp, while flushing stagnant water and toxic metabolites out of the system. The retention and uptake of nutrients within the swamp is necessary for the full benefits of the diversion to be recognized. The diversion will be operated to ensure that the residence time of the water within the swamp allows for nutrient uptake, thereby limiting the addition of nutrients to Blind River or Lake Maurepas. Diversion operations will also be adaptively managed to ameliorate salinity intrusion, especially to attempt to maintain salinity within a range that supports the growth of baldcypress and water tupelo. Most importantly, in instances of saltwater intrusion from a weather event, the diversion may be operated to flush saline water from the swamp once flood waters have receded.

Operation of the diversion will also be conducted in a way that recognizes the occasional need for low water levels in the swamp; it is during these times that naturally-recruited baldcypress and water tupelo seedlings have the opportunity to germinate and grow. Additionally, if seedlings are planted in the swamp to supplement natural recruitment, low water levels will be desired both during and after the planting. The diversion may not be run or may be run at a reduced rate during these times to allow seedlings time to grow to a height above which they will not be inundated.

Decisions on when and at what rate within the structure's 2000 cfs capacity to operate the diversion will be determined by CPRA, based on data and with input from technical experts and stakeholders. Operational considerations will account for current land use activities to include recreational and commercial interests. Monitoring will provide feedback for adaptive management of diversion operations which will be refined during the first years of operation and as conditions change over time. Because operations will be focused on improving the health of the swamp through multiple performance measures, operations will need to be flexible and able to respond to conditions in the swamp. However, regardless of this performance-based operation, the river stage will ultimately set the upper limit on diversion flow. Based on historical river stages and current conditions, the diversion as currently designed should be able to flow year-round and obtain a design output of 2000 cfs for approximately half the year. (Figure 4, Table 1).

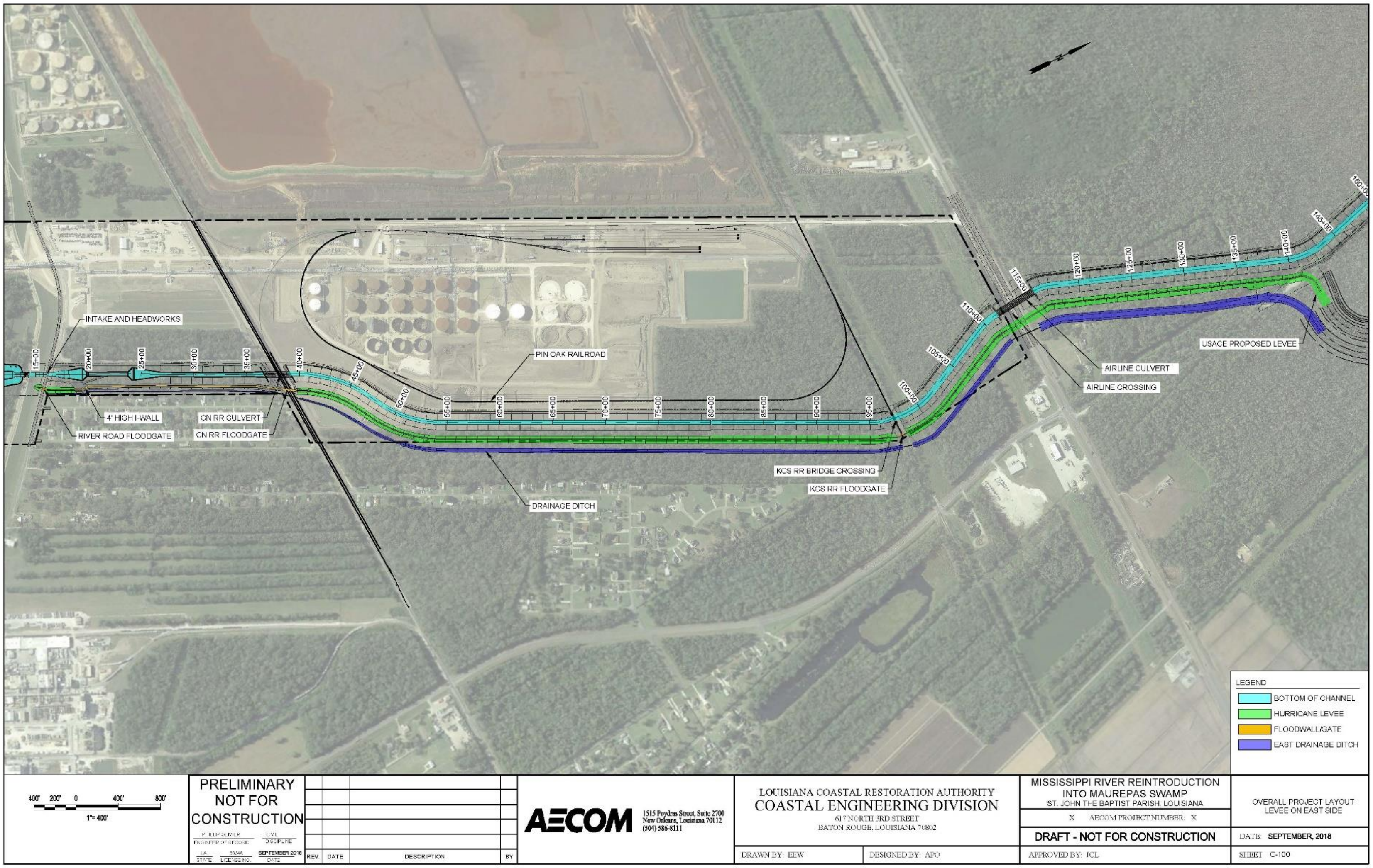

Figure 3: Maurepas project features and WSLP project features.

Physical operations of the diversion and associated structures will be managed by CPRA and performed by CPRA, its designee(s), or its contractors. Final design of the diversion structure will include a SCADA system to allow operators to monitor and control the diversion in real-time. An emergency operations plan will be developed with protocols for tropical storms and emergencies on the Mississippi River, such as oil or other chemical spills. The SCADA system will have the ability to connect real time to alarms or notifications from neighboring industries to allow managers to make expedited decisions related to emergency shut downs. Operations of the diversion and associated structures will also be coordinated with those of the pump station that will be part of the USACE WSLP Project.

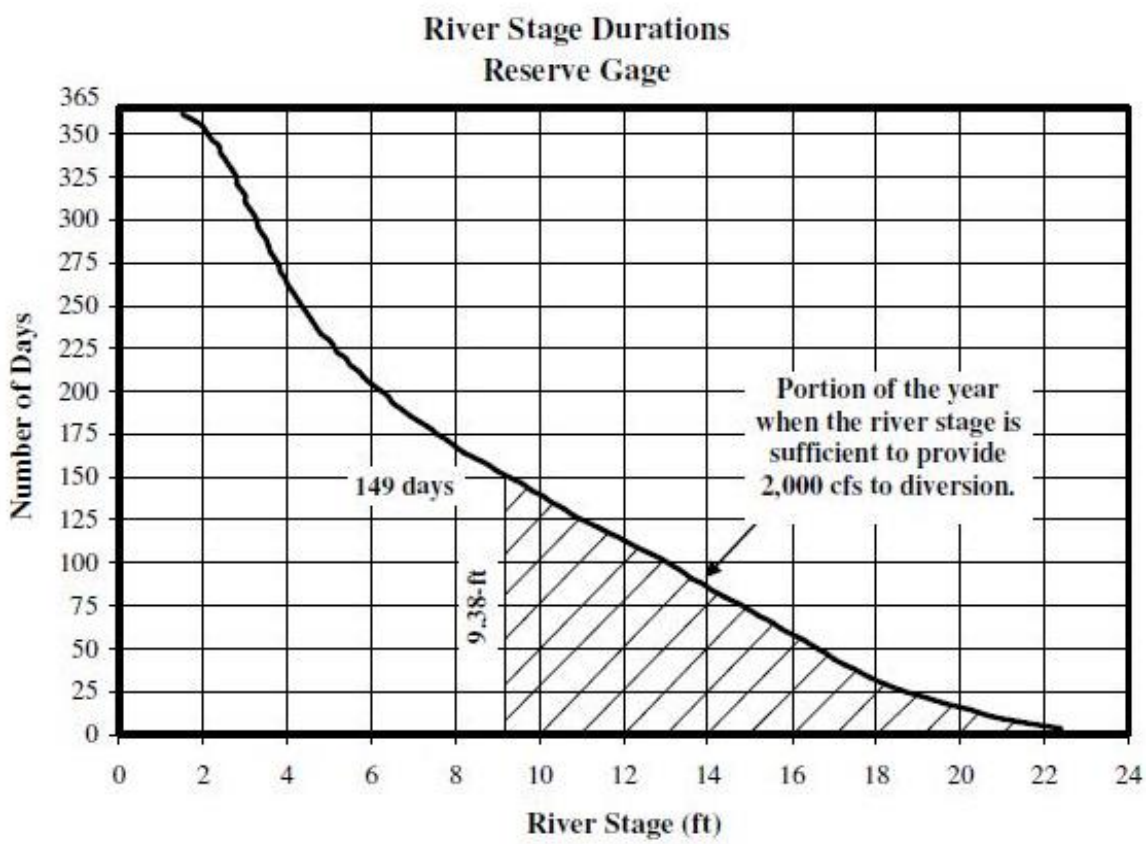

Figure 4. Expected number of days the Mississippi River will meet or exceed a given river stage at the USACE Reserve gage (01260). Figure from URS (2014).

Table 1. Required Mississippi River stage at USACE Reserve gage (01260) and the expected number of days the river will meet or exceed that stage in an average year to attain different diversion flow conditions. Table from URS (2014).

Flow Condition	Flow (cfs)	Mississippi River Stage Required (ft)	Historical River Stage Percentile	Average No. of Days Exceeding Stage per Year
Very Low Flow	1,000	4.92	37th	231
Low Flow	1,500	6.69	48th	191
Design Flow	2,000	9.38	59th	149
High Flow	2,250	10.83	65th	128

Outfall Management Features

The lateral relief valves will be operated on an as-needed basis to supply water to the area of the swamp between US 61 and I-10. These discharge valves must be operated manually, and real-time observation will be made to ensure they are functioning properly and flow is entering the areas as intended.

MAINTENANCE

All project features will be maintained to ensure that the project is functioning as designed. Maintenance activities will include routine maintenance of operable components and passive components, with repair or replacement of various features of the project as needed, based on monitoring information. Maintenance also includes removal of accumulated sediment and debris from the sedimentation basin, conveyance channel, and outfall management features. Additional details can be found in Appendix A.

MONITORING

In ecosystem restoration programs, monitoring is the term often associated with collecting data on ecological parameters that assist in the assessment of a project's ecosystem performance and to inform adaptive management. However, monitoring also refers to periodic inspection and documentation of the project's various structural components. Monitoring project features is critical to ensure they are functioning as designed and initially constructed and maintaining structural integrity. All data associated with monitoring of the structural integrity and function of project features will be documented in inspection records. This monitoring plan addresses both monitoring for structural integrity and function of project features as well as monitoring for ecosystem response. Monitoring for structural integrity and function of each project feature is detailed in Appendix A and monitoring for ecosystem response is summarized in Table 2. Each is also described below.

Monitoring for structural integrity and function

Headworks Features

Activities include visual inspection of the overall conditions of the headworks building, intake channel and sedimentation basin surfaces (including access roads, grades, side slopes, bottoms, and cross slopes), U-channels, and tie-ins for erosion, stability, sedimentation, scour, and other aspects of their structural integrity and function. Monitoring of the intake channel and U-channels also includes hydrographic surveying to ensure proper channel invert elevations and overall cross-sections and alignments are maintained. Culverts under the levee and LA 44 will be visually inspected for structural integrity (including settling or movement), erosion, or sedimentation. LA 44 will be inspected for pavement stability as well as surface and subsurface conditions. The sluice gates and ancillary mechanical and electrical components will be monitored for physical condition and functional operability. The SCADA system will be visually inspected and tested to verify signaling and control capabilities as well as the inter-connection with that of Pin Oak Terminals' emergency leak detection and shutdown system. Monitoring equipment will be periodically calibrated and data polling will be done to ensure continued operation. The overall configuration of the sedimentation basin will be monitored for stability and the sediment collected will be monitored for accumulation and need for removal as well as potentially testing for characterization of the sediment (dependent on potential use).

Conveyance Corridor Features

Activities include inspection of side slopes, crown roadways, and wetted surfaces of the conveyance channel for stability, erosion, surface condition, base failures, excessive vegetative growth, debris and sediment accumulation, and potential flow problems such as scour, eddies or stagnant water. The crossings under the CN RR, KCS RR, US 61, and I-10 will be monitored for structural integrity, erosion or scour, debris or sediment accumulation, and potential flow problems. All bridge structures and railroad infrastructure components will be monitored according to Louisiana Department of Transportation and Development (LDOTD) and American Railway Engineering and Maintenance-of-Way Association (AREMA) standards and those specific to CN RR and KCS RR.

Outfall Management Features

Monitoring of outfall management features includes visual inspection of stability of side slope connections between the conveyance channel and the discharge valve inlets and the condition of the outlet structures as well as their function during operation as described above. The check valves on the drainage pipes under I-10 will be inspected for solidity and function, debris or sediment accumulation, erosion, or scouring. The weirs on Bayou Secret and Bourgeois Canal will be monitored for settlement or loss of material and accumulation of debris or sediment. Observation during high flows will be closely monitored to observe potential bypassing, backwater effects, and overall effectiveness. The embankment cuts to the abandoned railroad grade will be monitored for stability, sloughing, erosion, debris, or sediment accumulation. Water flow and surface elevations on either side will also be inspected.

Monitoring for ecosystem response

Monitoring ecosystem parameters is the key to the evaluation and learning components of adaptive management. To be effective, monitoring designs must be able to discern ecosystem responses caused by project implementation versus natural variability. Monitoring should be conducted at project and system-wide scales to evaluate long-term, large-scale status and trends and short-term project performance.

The ecological monitoring plan for this project is largely structured after the recommendations provided in the report *Performance Measures for a Mississippi River Reintroduction Into the Forested Wetlands of the Maurepas Swamp* (Krauss et al. 2017). This monitoring plan contains most of the monitoring elements recommended in the report, and as such, will provide an account of the swamp's response to the diversion within the project area. CRMS sites within and neighboring the project area will be utilized for monitoring, while additional project-specific stations will be added in select areas that are lacking monitoring stations. When appropriate, the CRMS sites will serve as sampling locations for the expanded sampling parameters that will be incorporated into the monitoring plan. SWAMP monitoring stations within and surrounding the project area will also be utilized as a source of data collection. The monitoring outlined in this plan is subject to change based on the final approved funding and in response to knowledge gained prior to and during project implementation.

Due to the difficult conditions associated with monitoring in a swamp, preliminary site assessments will be conducted to determine the suitability of proposed station locations and to identify alternate locations when necessary. Monitoring will be conducted prior to diversion operations to determine baseline conditions and post-construction during the project monitoring timeline. The frequency of monitoring will be greatest prior to and within the first few years of project completion to inform diversion operations and assess the short-term effects of the diversion on the swamp and neighboring waterways. Monitoring reports will be developed at appropriate intervals yet to be determined.

Data management and quality assurance/quality control will follow established CRMS and SWAMP protocols where applicable and data will be made publically available through CPRA's Coastal Information Management System (CIMS). Data collection efforts that fall outside of these programs (e.g. radioisotope dating of sediment, isotope analysis of water samples) will require the development of new protocols.

The monitoring elements described below are organized according to the performance measures they address as listed in Krauss et al. (2017).

Establishing a hydrologic regime consistent with swamp forest sustainability/Ameliorating salinity intrusion

Water elevation: Water elevation monitoring is imperative to detect variability in water level that occurs both naturally and as a result of the diversion, to guide diversion operations, and to establish a picture of water movement throughout the project area. Water elevation monitoring is also important to ensure that proper flooding/drying periods are maintained within the swamp to allow for the germination and growth of baldcypress and water tupelo seedlings. Water elevation is measured hourly at 11 CRMS continuous recorder stations within the project area.

Salinity monitoring: Continuous (hourly) monitoring of salinity in the project area will demonstrate whether salinity is remaining within a range that supports the growth of baldcypress and water tupelo. It will also capture any salinity intrusion from Lake Maurepas that results during significant storm events. Ten CRMS continuous recorder stations currently record salinity within the project area. Porewater salinity is also collected at CRMS stations during servicing.

In addition to the CRMS stations in the project area, four additional continuous recorder hydrographic stations are planned for installation. Monitoring is proposed to begin one year prior to the initiation of diversion operations and to continue throughout the project's life. The number of project-specific stations may eventually be reduced if data show no significant difference in salinity and water elevation between stations.

Isotope analysis of water samples: Stable isotopes of oxygen and hydrogen ($\delta^{18}O$ and $\delta^{2}H$) are useful to determine water residence times and to identify water sources with distinct geographic origin (e.g. Mississippi River vs. local rainfall). Once the diversion begins operation, analysis of water samples collected within the project area will identify areas where the diversion water is or is not reaching during different operational flow rates up to the project design limits of 2000 cfs. Isotope analysis of water samples is proposed to occur every month to every other month for the year prior to and after the initiation of diversion operations. The frequency of analyses will then be reduced to periodic evaluations throughout the project life. Additional analyses may be conducted after significant changes in operational flow or to investigate suspected alterations in water distribution in the system.

Synoptic Surveys: Acoustic Doppler current profiler (ADCP) data will be collected within navigable water channels within and bordering the project area to create a water velocity and depth profile at each station. *In situ* discrete data collection will include dissolved oxygen (DO), chlorophyll a (chl a), turbidity, specific conductance, pH, and temperature. Laboratory analyses to accompany these surveys will include suspended sediment concentration and chl a (required for comparison with *in situ* chl a readings). In narrower channels that have low flow and are impeded by debris, an acoustic Doppler velocimeter may be used instead. Synoptic surveys are proposed to occur at intervals ranging from every other month to seasonally in the year prior to the start of diversion operations. During the first year of diversion operations, synoptic surveys may be conducted more frequently to capture changes in flow. The frequency of analyses will then be reduced to periodic evaluations throughout the project life. Additional analyses may be conducted after significant changes in operational flow or to investigate suspected alterations in flow in the system.

Increasing rates of soil surface elevation gain

Surface elevation change/accretion: Measuring surface elevation change and accretion can be difficult or unattainable in areas of the Maurepas Swamp due to continual or frequent inundation, floccular soils, and floating marsh. Prior to the installation of new stations, proposed locations will be visited to determine if the collection of quality data will be possible. Six new surface elevation change and accretion data collection stations are proposed for the project, which will complement the seven existing CRMS stations in the project area. Station installation and data collection will follow CRMS protocol and will utilize rod surface elevation tables (RSETs) to measure surface elevation change and feldspar markers to measure accretion (Folse et al. 2018). Approximately five years of biannual (twice yearly) pre-diversion surface elevation data collection are planned, with data collection continuing biannually after the start of diversion operations and then possibly modifying to a less frequent interval after year 10.

Radioisotope dating of sediment: Radioisotope dating of sediment cores will use ^{210}Pb, ^{226}Ra, and ^{137}Cs to assign dates to specific depths of the core. Radioisotope dating provides an alternate method to determine sediment accretion rates within the swamp, which may be difficult to assess in some locations using the feldspar marker horizon method. This methodology also allows for the determination of historic accretion rates. Analysis of cores is proposed at the seven existing CRMS accretion stations and at the new project-specific accretion stations. Sampling is proposed to be conducted once pre-diversion operations and four times after the diversion begins operations.

Increasing forest structural integrity

Swamp vegetation: In addition to the ten pre-existing CRMS sites, six to twelve project-specific swamp vegetation sites will be established in the project area. The final number established will be dependent on the suitability and accessibility of the proposed stations as determined during the site assessments. Site design and monitoring will follow CRMS swamp monitoring protocols (Folse et al. 2018). Each tree within the overstory stations (20 m x 20 m) will be tagged and diameter at breast height (DBH) will be measured, allowing for tree-specific and species-specific monitoring of growth rates throughout the project's life. Monitoring of the understory (not currently measured at CRMS sites) and herbaceous layers will provide data on recruitment and survival of seedlings and will allow for an assessment of how these vegetation layers transition in response to the diversion. Vegetation surveys are proposed to occur twice pre-diversion and a minimum of five times after the diversion begins operations.

Habitat analysis/ remote sensing: The United States Geological Survey (USGS) will utilize both CRMS-collected color infrared (CIR) photography and satellite imagery to classify habitat in the project area according to the National Wetlands Inventory Wetlands and Deepwater Habitats Classification System (Cowardin et al. 1992). Habitat analysis will allow for a project-wide quantification of forest, scrub-shrub, and herbaceous habitats and will capture how these habitats change in acreage over the project monitoring life. Habitat analysis is proposed to be conducted once pre-diversion and four times after the diversion begins operations.

Facilitating nutrient uptake and retention

Soil properties: Soil bulk density and percent organic matter are currently analyzed from cores collected at 10 CRMS sites in the project area following CRMS methodology (Folse et al. 2018). Additional parameters proposed to be added to the analysis of CRMS cores as part of project monitoring include pH, soil salinity, total nitrogen (TN), total phosphorous (TP), and carbon (C), as well as iron, magnesium, calcium, copper, manganese, potassium, and zinc. Six to 12 additional sampling sites in the project area and up to six reference sampling sites (CRMS sites outside of the project area) are recommended. Soil sampling and analysis are proposed to be conducted once pre-diversion and four times after the diversion begins operations.

Water quality: Water quality monitoring will be conducted at the 11 CRMS hydrographic monitoring stations in the project area, with additional stations proposed for Lake Maurepas, Hope Canal, Tent Bayou, Dutch Bayou, the Amite River Diversion Canal, Reserve Relief Canal, Mississippi Bayou, and Blind River. Additional water quality data will be utilized from SWAMP stations in the vicinity of the project area. Total suspended sediment (TSS), chl a, nitrate (NO_3^-), ammonium (NH_4^+), phosphate (PO_4^{-3}), TN, TP, and silicate (SiO_4) are proposed to be measured. During sample collection, discrete readings of dissolved oxygen, salinity, specific conductivity, temperature, and pH will also be taken. One year of monthly water quality sampling is recommended in the year prior to and the year following the initiation of diversion operations. If data show that nutrient uptake, even at maximum diversion flow, is occurring in the swamp at a rate that will prevent excess nutrients (nitrate in particular) from impairing the health of Lake Maurepas, the frequency of water quality monitoring will be reduced. Routine periodic sampling will continue throughout the life of the project, with the option of additional investigative samplings in response to episodic events.

Table 2. Proposed monitoring elements and timeline for the project.

Proposed Monitoring Elements and Timeline for the Project			
Monitoring Category	**Data Collection**	**Frequency**	**Specifications**
Hydrology: Establishing a hydrologic regime consistent with swamp forest sustainability/ameliorating salinity intrusion	Continuous recorders: water level, specific conductivity, salinity, temperature	Hourly	Data collected through CRMS; project-specific stations will be added one year prior to start of diversion operations.
	Isotope analysis of water samples	Variable	Sampling/analysis will occur monthly to every other month in year prior to and after start of diversion operations; continued at reduced rate thereafter.
	Synoptic surveys: water velocity, depth, DO, chl a, turbidity, specific conductivity, pH, temperature, suspended sediments	Variable	Surveys will occur every other month to seasonally in year prior to diversion operations and monthly to seasonally in the year after the start of diversion operations; continued at reduced rate thereafter.
Surface elevation change/accretion: Increasing rates of soil surface elevation gain	Surface elevation change: RSETs	twice yearly/ variable	Data are collected twice yearly through CRMS; additional project-specific stations planned for installation; data collection will occur twice yearly for up to 5 years pre-diversion operations and will continue twice yearly for at least 10 years after the start of operations, thereafter possibly modifying to a less frequent interval.
	Accretion (feldspar)	twice yearly/ variable	Data are collected twice yearly through CRMS; additional project-specific stations planned for installation; data collection will occur twice yearly for up to 5 years pre-diversion operations and will continue twice yearly for at least 10 years after the start of operations, thereafter possibly modifying to a less frequent interval.
	Accretion (radioisotope dating of sediment cores)	variable	Data will be collected once pre-diversion operations and 4 times after the start of operations.

Proposed Monitoring Elements and Timeline for the Project			
Monitoring Category	**Data Collection**	**Frequency**	**Specifications**
Vegetation: Increasing forest structural integrity	Vegetation surveys	Variable	Data are collected through CRMS, with herbaceous data collection annually and forested data collection every 3 years; project-specific stations will be added prior to the start of diversion operations; monitoring will occur twice pre-diversion operations and will occur a minimum of 5 times after the start of operations.
	Habitat analysis	Variable	Analysis will be conducted once pre-diversion operations and 4 times after the start of operations.
Nutrients (sediment/water): Facilitating nutrient uptake and retention	Soil properties: % organic matter, bulk density, pH, soil salinity, TN, TP, C, iron, magnesium, calcium, copper, manganese, potassium, and zinc	Variable	% organic matter content and bulk density are collected through CRMS every 6 years; project-specific stations will be established pre-diversion operations; sampling/analysis will occur once pre-diversion operations and 4 times after the start of operations.
	Water quality: TSS, chl a, nitrate, ammonium, phosphate, TN, TP, and silicate	Variable	Monthly sampling/analysis will occur in the year pre-diversion operations and the year post-construction; sampling/analysis will occur at a reduced frequency after the first year of diversion operations.

ADAPTIVE MANAGEMENT

As previously stated, this project will be adaptively managed to assist in achieving the desired project outcomes while reducing undesirable impacts. Several adaptive management elements have been addressed and explained earlier in this document, including identifying/defining the problem, project goals and objectives, modeling tools, uncertainties, project design, monitoring, and data management. This section will discuss expected project outcomes, assessment and evaluation, potential adaptive management actions, and decision-making.

The expected project outcomes are enhanced health and sustainability of the coastal forest habitat in the project area and reduction or minimized loss of coastal forest habitat. Expectations of habitat response can be expressed as performance measures (PM) and, as previously discussed, CPRA worked with the TAG to develop PMs that provide information on key attributes of forested wetland ecosystem function, including hydrology, salinity, nutrients, accretion, and vegetation. Because of the large area of influence for this project, the project will not have consistent effects in all locations. There are location-specific levels of swamp degradation and, therefore, specific needs for each condition class may not be attainable to the same degree at all locations. In addition, project effects will vary with respect to time, and monitored parameters are collected at time intervals reflective of the ability to detect changes of each parameter, especially in their influence of the habitat. Therefore, the project has both short- and long-term PMs to capture both spatial and temporal variability. If project outcomes are not as expected, the consideration of adaptive management actions will be triggered.

After the data are collected and managed, they will be analyzed at a time frame that is appropriate for each parameter. These assessments will determine how the ecosystem is responding to the project and should identify trends or trajectories in the project area. The frequency of these assessments will be determined later, but with the hydrologic assessments such as water levels and velocity, as well as water quality analyses, potentially occurring quickly, since they may influence operations within the first few months. Other assessments are estimated to be conducted in the project's first three to five years and would be documented by periodic monitoring reports.

The need for adaptive management actions will be identified based on the monitoring data and associated assessments. For example, if the assessment(s) indicates that Mississippi River water is not reaching the desired locations, action may be needed. The primary means of adaptively managing this project will involve adjustments to the operation of the diversion structure. Secondarily, operation of outfall management features may be adjusted. The project will be operated to best meet ecosystem needs by targeting the desired water, nutrient, and sediment flow into the project area.

As was discussed in the Operations section, operational adjustments may be needed due to a variety of factors including Mississippi River conditions, seasonal environmental trends, and weather patterns. In addition, operations will need to be flexible to meet the needs of the receiving basin, including the potential for drawdowns to promote seedling establishment and maximize nutrient uptake. It is expected that operations will vary annually, based on these factors. Operational changes may include timing, duration, and frequency of operations. As has been successful with previous freshwater diversions, a pulsing operational regime will be considered.

In addition to changing operational regimes, other potential adaptive management measures may be needed to improve internal hydrology and distribution of river water. These features could include additional spoil bank gapping, water control structures, check valves, lateral relief valves, or cuts in railroad embankments to assist with achieving the desired hydrology in the project area. Another action could include location-targeted vegetative plantings to assist with the development of the desired vegetative community.

Specific adaptive management actions may be identified and recommended. These recommendations could be made by a variety of entities, including state and federal agencies, local entities, non-governmental organizations, not-for-profit organizations, and others. Recommendations will be submitted for consideration to decision-makers and varying levels of approval may be required to implement any adaptive management actions. Specific governance with respect to adaptive management of this project will be affected by the source of project construction funds. Those involved with governance will be CPRA, USACE, Pontchartrain Levee District, LDWF, as well as other landowners, parishes, and those with responsibilities for project operation and maintenance, among others.

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APPENDIX A: Operations, Monitoring, and Maintenance of Project Features

Project Features	Operations	Monitoring	Maintenance
Headworks Features			
Intake Channel (Riprap -lined channel excavated in the Mississippi River batture)	N/A	Activities include observing the condition of the channel riprap armoring and the tie-ins to the revetment along the Mississippi River levee slope. The inspections will consist of both visual observations and hydrographic surveying to ensure that neither deposition nor scouring has significantly affected the channel invert elevation or the overall cross-section.	Maintenance, including the replacement of riprap, repair of revetment, and/or the removal of deposited material would be conducted based on the inspection findings.
Concrete U-channels (Tie-ins to intake channel)	N/A	Activities include inspecting the channels visually for structural integrity as well as potential erosion or sedimentation. Hydrographic surveying will be conducted concurrent with the intake channel survey to ensure that the alignment and invert of the U-channels remains unchanged.	Maintenance, including repair of the concrete channels or the removal of deposited material will be conducted based on the inspection findings.
Sluice Gates & Actuators (Hydraulically actuated vertical sluice gate structure built on the flood side of the Mississippi River levee)	Operation of the hydraulically actuated sluice gates will be according to the diversion operational regime established. In addition, routine operation of the gates and hydraulic actuators will be conducted on a periodic basis to ensure their condition remains fully functional.	Activities include observing the physical condition and functional operability of the gates, hydraulic actuator systems, and ancillary mechanical components. The incoming electrical supply to the overall headworks and specifically to the gates and actuators will also be inspected.	Activities will include routine items, such as lubrication, replacement of worn components, painting, etc., which will be guided by the monitoring findings. Additional maintenance actions will include the repair and replacement of damaged or inoperable components.

Project Features	Operations	Monitoring	Maintenance
Culverts under Levee (Box culverts will be installed to convey river water under the levee and River Road)	N/A	Activities include visually inspecting the culverts for structural integrity as well as potential erosion or sedimentation build-up.	Maintenance will consist of structural repairs or removal of deposited material, as indicated by the inspections.
Headworks Building and Concrete Structures (Includes control room)	N/A	Activities include visually inspecting the condition of the headworks building, including its structure and ancillary on-site facilities.	Maintenance will consist of structural repairs to the building, structures and ancillary facilities.
Supervisory Control and Data Acquisition (SCADA) System	Operation of the SCADA system will be primarily autonomous, with the ability for manual operation on an as-needed basis. The SCADA system will be used to both automatically record the operation of the various headworks components and to control their operation remotely. In addition to its autonomous operation, the system will be manually operated at a minimum on a monthly basis to ensure that the reporting functions and operational control remains fully functional.	Activities include visual inspection, along with electrical/electronic testing to verify signaling and control capabilities. Monitoring will also include routine testing of the inter-connection of the headworks SCADA system to that of the Pin Oak Terminals emergency leak detection and shutdown system. This will ensure that any potential leaks can be detected and that the system can be shut down quickly to eliminate the transport of any potential spill into the diversion channel.	Maintenance of the SCADA system will involve the repair and/or replacement of components as indicated by the monitoring results and well as scheduled annual maintenance of the system components.

Project Features	**Operations**	**Monitoring**	**Maintenance**
Access Roads (To access the headworks features and sedimentation basin)	N/A	Activities include visually inspecting the condition of the roads, including their grades and cross-slopes, as well as their overall condition.	Maintenance will consist of re-grading, along with base and surface repairs, as needed, to ensure continuous access to the headworks facilities.
Monitoring Equipment (Flow detection devices, water quality parameter probes, etc.)	Operation of the monitoring equipment, such as flow detection devices, water quality parameter probes, etc. will occur automatically to collect the requisite data deemed necessary to successfully operate the diversion. Depending upon the device, retrieval of the monitored information may be remote or require a personnel visit to extract the recorded information from the monitoring device.	Activities include periodic calibration of various devices to ensure detection accuracy as well as data polling to insure continued operation.	Maintenance will consist of routine replacement of standard component elements that degrade in the normal course of wear and tear, as well as instrumentation repair and replacement, as needed.
River Road (LA Hwy 44) Culverts (Box culverts will be installed to convey river water under the levee and River Road)	N/A	Activities include inspecting the culverts and outflow U-frames visually for structural integrity, as well as for potential erosion or sedimentation build-up, along with observation of settling or movement of the structures. Examination of the soundness of the roadway over the culverts will also be a key element of the monitoring plan. Inspections will be made for pavement stability, as well as surface and subsurface conditions.	Maintenance will include repair of eroded culvert components, as well as debris removal, as needed. Additional maintenance activities will include the repair of subsurface base failures, damaged structural elements, and the River Road roadway surface (per Louisiana Department of Transportation and Development (LDOTD) requirements), as indicated by the monitoring results.

Project Features	Operations	Monitoring	Maintenance
Sedimentation Basin (Earthen-lined basin to settle and remove large sediment particles entrained in the diverted flow-stream)	N/A	Activities include inspection of the access roadways to the basin for stability, grade and slope to ensure continued access to the basin. The condition of the basin side slopes and bottom will also be observed to ensure that the geometric configuration of the basin remains stable. The monitoring and recording of sediment accumulation will be conducted to assess the need for clean-out. Potential additional monitoring may include sampling and geotechnical analyses to characterize the sediment captured (e.g., specific gravity determination, sieve analysis of grain size distribution, etc.).	Activities will include the repair of any damage to the access roads, side slopes, and bottom, as needed. A key maintenance activity will be the excavation, removal, and haul-off of the accumulated sediment. Based on the estimated accumulation rate, it is anticipated that sediment removal will be required every six months. The frequency of the basin clean-out will be adjusted based on the actual sediment accumulation rate as the diversion is operated over time.
Conveyance Corridor Features			
Conveyance Channel (A new channel from the sedimentation basin to just north of US 61, where the constructed channel would intersect Hope Canal. An improved channel along the existing Hope Canal from just north of US 61 to I-10. Includes channel, guide levees, crown roadways)	N/A	Activities include inspection of the channel side slopes for stability, erosion problems, establishment of protective turf, and possible leaks. The crown roadways will also be inspected for potholes, sloughing, loss of surfacing materials, and potential base failures or soft spots that require repair to ensure surface integrity. The wetted surface of the inside of the channel will be visibly examined for vegetative growth, observable debris and\or sediment accumulation, and problematic water flow regime phenomena, e.g., scour, eddies or stagnant areas.	Activities will include the repair of the crown roadways to maintain access throughout the length of the conveyance channel. The repair of stability concerns, erosion problems, and leaks observed in the guide levees will be crucial to maintaining a stable channel cross-section. Restoration of as smooth an internal channel surface as possible by removing debris, repairing scour holes, and clearing areas of excessive vegetation will be key to preserving the maximum flow capacity of the diversion.

Project Features	Operations	Monitoring	Maintenance
Canadian National Railroad (CN RR) Crossing (Box culverts will be installed to cross under the CN RR)	N/A	Activities include structural inspection of the culverts, observation of erosion at the culvert inlets and outlets, examination for the accumulation of debris and\or sediment, and surveillance for evidence of potential flow problems, e.g., eddies, stagnant areas, etc. The monitoring will also include the observance of the railroad horizontal and vertical alignment stability, plus the condition of the RR infrastructure components. All of the railroad specific inspections will be conducted as per the procedures and schedule dictated in the national AREMA standards as well as the requirements specific to the CN RR.	Maintenance will include the repair of any deteriorated areas of the culverts, the removal of debris and sediment, as well as any corrective measures required to address flow-related problems. Maintenance of the railroad elements will be dictated by the monitoring inspection findings as well as the routine maintenance activities required by the AREMA and CN RR standards.

Project Features	Operations	Monitoring	Maintenance
Kansas City Southern Railroad (KCS RR) Crossing (A bridge will be constructed over the conveyance channel)	N/A	Activities include inspection of the railroad bridge substructure and superstructure components. The horizontal and vertical stability of the track, the condition of the approach slabs, and the erosion and\or sediment build-up around bridge piers will also be observed. All of these inspections will be conducted per the AREMA and KCS RR standard procedures and scheduled intervals. The condition of the conveyance channel itself underneath the railroad bridge will be visibly examined for slope stability, observable debris and\or sediment accumulation, and potentially troublesome flow phenomena, e.g., scour, eddies, stagnant areas, etc. The wetted surface of the channel under the bridge will be checked for excessive vegetative growth. The guide levee side slopes will be examined for stability, leaks, erosion problems, and turf establishment. The levee crown roadways will also be inspected for both surface and subsurface conditions to ensure continued access along the diversion.	Maintenance activities will involve the repair or replacement of any structurally deteriorated elements of the bridge sub- and super-structure, approach slabs, and piers. Repairs to any sections of track or ancillary elements will also be conducted as part of the maintenance activities. The maintenance of the railroad components will be conducted based on the monitoring inspection findings as well as the routine maintenance activities required by the American Railway Engineering & Maintenance-of-Way (AREMA) and KCS RR standards. All railroad repairs will be made per the specifications outlined in the referenced standards. Remedial actions to maintain and/or restore the conveyance channel bank will be prioritized to first maintain the structural integrity of the bridge, then address local repairs needed, and finally, maintain as hydraulically efficient a section as possible. Maintenance of the levee top roads will be directed by the findings of the monitoring program.

Project Features	Operations	Monitoring	Maintenance
Airline Highway (US 61) Crossing (Box culverts will be installed to cross under US Highway 61)	N/A	Monitoring activities will address the integrity of the culverts and the roadway. Inspection of the culverts will include examination of the structural elements and potential subsidence. The culvert inlets and outlets will be checked for evidence of erosion, accumulation of sediment and\or debris, and adverse flow phenomena, e.g., scour, eddies or stagnant areas. Inspection of the roadway will include assessment of its horizontal and vertical alignment as well as the surface condition of the travel lanes and shoulders. The road will be checked for areas of potential settlement, base failures, and subsurface deterioration as well as potholes, rutting, and other riding surface issues.	Activities will include the repair of any structural deterioration of the culverts along with any efforts needed to correct or prevent potential subsidence. Repair of eroded areas and the removal of sediment and debris from the culverts and their inlets and outlets to the conveyance channel will be part of the routine maintenance program. Roadway maintenance activities (to be conducted by the LDOTD and per their standards) will include surface and subsurface repairs to prevent deterioration and maintain a sound travel surface.
Interstate 10 (I-10) Crossing (Conveyance via existing revetment-lined channel under existing bridge)	N/A	Activities include inspection of the I-10 bridge sub- and super-structure, the bridge piers, the channel lining revetment, and the roadway. As part of the diversion project, inspection around the bridge piers will be conducted to check for erosion and\or sediment build-up on an annual basis. The condition of the cement bag/concrete revetment system that comprises the channel lining protection underneath the bridge will be inspected to ensure that the configuration of the channel cross section is stable. The tie-in of the revetment system to the bridge approach slabs will be examined to further document the stability of the bridge\channel crossing. Monitoring data collected by the LDOTD on the roadway horizontal and vertical alignment will be entered into the diversion channel inspection record.	Activities will include repairs to the channel lining revetment, as indicated by the inspections. Maintenance dredging and/or filling of scour holes around the bridge piers or anywhere else within the channel cross section will also be performed, on an as-needed basis.

Project Features	Operations	Monitoring	Maintenance
Outfall Management Features			
Manual Discharge Valves (Lateral relief valves off the conveyance channel, N of proposed pumping station & S of I-10)	Operation of the manual discharge valves will occur on an as-needed basis to supply water to the area of the Maurepas Swamp south of Interstate 10.	Monitoring activities will include visual inspection to evaluate the stability of the conveyance channel slopes at the valve inlets and the condition of the discharge outlet structures. Manual operation of the valves will be performed to ensure that they are in operable condition and to observe whether the system intakes flow from the channel and discharges it into the southern swamp as intended through the outlet structures.	Activities will consist of lubricating and operating the valves on an annual basis, as well as repairing any damage and/or subsidence to the collection and discharge system observed during monitoring.
Check Valves under Interstate 10 (I-10) (One-way check valves on all existing culverts underneath I-10 from LA 641 to the Mississippi Bayou overpass)	N/A	Activities include visual inspection of the connections between the valves and their respective drainage pipes to assess their solidity. Visual inspection for potential debris and/or sediment accumulation in the pipe, valve, or nearby area that could potentially prevent proper valve closure; and for erosion or undermining effects that could lead to a pipe failure which could prevent proper function by either closing off the pipe, preventing drainage to the north, or by-passing the valves enabling drainage to the south.	Activities will include repairing pipe/valve connections, as needed; removal of debris and/or sediment accumulation; and replacing damaged pipe sections, as indicated by the monitoring observations.

Project Features	Operations	Monitoring	Maintenance
Weirs on Bayou Secret & Bourgeois Canal (Will be constructed at their intersections with Blind River)	N/A	Monitoring activities will consist of observing any settlement of the weirs, accumulation of debris and\or sediment, and potential loss of material from the weirs. Water surface elevations on both sides of the weirs will be observed when significant flow is being routed from the Maurepas Swamp into Blind River. Particular attention will be paid to whether there is a significant volume of flow that by-passes the weirs on either side. The data will be recorded for evaluation of the backwater effects created by the weirs and determination of their effectiveness.	Activities will include the replacement of riprap lost due to settlement or other reasons and the removal of accumulated debris and\or sediment. Depending upon the monitoring observations and their assessment, additional material may be added to the weirs, material may be removed from the weirs, or the invert elevations and extents of the weirs may be revised.
Embankment Cuts (Cuts will be made in the abandoned railroad embankment N of I-10 and E of Blind River)	N/A	Activities include observing the stability of the cut sections and noting any sloughing, erosion, or debris and\or sediment accumulation. The movement of water through the embankment cuts will be monitored by visual inspection of flow and measurement of water surface elevations on either side.	Activities will include repairing any embankment areas degraded by sloughing or erosion and reshaping the cut faces to create stable surfaces. The removal of accumulated debris and\or sediment will also be performed. Depending upon the observed water movement, the cuts may be widened, deepened, or extended perpendicular to achieve the desired flow.

APPENDIX B: Prior Studies and Reports

Battelle. 2005. Phase 1 Assessment of Potential Water Quality and Ecological Risk and Benefits From a Proposed Reintroduction of Mississippi River Water into the Maurepas Swamp. Final Report. U.S. Environmental Protection Agency, Region 6, Dallas, Texas. EPA/OCPD Contract No. 68-C-03-041. WA#2-32. 67 pp. plus appendices.

Battelle. 2007. Field Survey Report for Limited Phase II Assessment of Ecological Risks from a Proposed Reintroduction of Mississippi River Water into Maurepas Swamp, Louisiana. Attachment A - In Battelle (2008) Limited Phase II Assessment of Ecological Risks of Contaminants from a Proposed Reintroduction of Mississippi River Water into Maurepas Swamp U.S. Environmental Protection Agency, Region 6, Dallas, Texas. EPA Contract No. 68-C-03-041. WA# 4-40. 135 pp.

Battelle. 2008. Limited Phase II Assessment of Ecological Risks of Contaminants from a Proposed Reintroduction of Mississippi River Water into Maurepas Swamp U.S. Environmental Protection Agency, Region 6, Dallas, Texas. EPA Contract No. 68-C-03-041. WA# 4-40. 32 pp. plus appendices.

Coastal Environments Inc. 2008. Cultural Resources Survey of the River Reintroduction Corridor, Maurepas Swamp (PO-29), St. John the Baptist Parish, Louisiana. Final Report.by Douglas C. Wells. Prepared for U.S. Environmental Protection Agency, Water Quality Protection Division, Dallas, Texas. Contract No. GS-10F-0445N. CEI Job No. 27064. LA DOA Report No. 22-3023. 53 pp.

Day, J.W., R.R. Lane, G.P. Kemp, H.S. Mashriqui, and J.N. Day. 2001. Mississippi River Diversion into the Maurepas Swamp: Water Quality Analysis, Draft Final Report. In Diversion into the Maurepas Swamp: Complex Project Coastal Wetlands Planning, Protection, and Restoration Act. U.S. Environmental Protection Agency, Region 6, Dallas, TX. Report WA#5-02.

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Day, J.W., I. Mendelssohn, G.P. Kemp, E. Hyfield, and J. Visser. 2004. A Feasibility Analysis of the Impacts of Discharge of Non-Contact Industrial Cooling Water to Forested Wetlands in the Vicinity of Uncle Sam, Louisiana. School of the Coast and Environment, Louisiana State University. Baton Rouge, LA. 20 pp.

Fox, D.M., P.C. Stouffer, D.A. Rutherford, W.E. Kelso, M. LaPeyre, and R. Baumbarger. 2007. Impacts of a Freshwater Diversion on Wildlife and Fishes in the Maurepas Swamp. Prepared by Louisiana State University, School of Renewable Natural Resources, Baton Rouge, LA. Prepared for U.S. Environmental Protection Agency, Region 6, Dallas, TX. Agreement #DW-14-95045601-1.Work Order 79

Kemp, G. P., H.S. Mashriqui, F.W. Jones, and R. Cunningham, R. 2001. Hydrologic modeling to evaluate the potential to divert Mississippi River water into the swamps south of Lake Maurepas. Appendix C - Diversion into the Maurepas Swamps: Complex Project Coastal Wetlands Planning, Protection, and Restoration Act. U. S. Environmental Protection Agency, Region 6, Dallas, TX, Report WA #5-02. 52pp.

Kirk, J.P., K.J. Killgore, and J.J. Hoover. 2007. Report to the Environmental Protection Agency (EPA): Evaluation of Potential Impacts of the Lake Maurepas Diversion Project to Gulf and Pallid Sturgeon (Draft). Environmental Laboratory, Engineer Research and Development Center, Vicksburg, MS. 18 pp.

Lee Wilson and Associates, Inc. 2001. Diversion into the Maurepas Swamps. A complex project under the Coastal Wetlands Planning, Protection, and Restoration Act. Prepared for: the U.S. Environmental Protection Agency, Region 6, Dallas, Texas. Contract No. 68-06-0067 WA#5-02. 59 pp.

Lindquist, D. 2008. Draft 30% Ecological Review River Reintroduction into Maurepas Swamp CWPPRA Priority Project List 11. State No. PO-29. Louisiana Department of Natural Resources. Baton Rouge, LA. 13 pp.

RECON Environmental, Inc. 2009. Noise Technical Report for the Maurepas Swamp Mississippi River Diversion Project, PO# EP086000137, Saint John the Baptist Parish, Louisiana. Prepared for U.S. Environmental Protection Agency, Region 6, Dallas, Texas. Recon Job No. 4719. 39 pp.

Shaffer, G.P., J.M. Willis, S. Hoeppner, A.C. Parsons, and M.W. Hester. 2001. Characterization of Ecosystem Health of the Maurepas Swamp, Lake Pontchartrain Basin, Louisiana: Feasibility and Projected Benefits of a Freshwater Diversion. Appendix E - Diversion into the Maurepas Swamps: Complex Project Coastal Wetlands Planning, Protection, and Restoration Act. U. S. Environmental Protection Agency, Region 6, Dallas, TX, Report WA #5-02. 48 pp.

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URS Corporation. 2008. Geotechnical Investigations for Lake Maurepas Diversion Canal, St. John the Baptist Parish. URS File No. 1001431.30001. Prepared for: State of Louisiana Department of Natural Resources, Baton Rouge, LA. LDNR Contract No. 2511-06-10. 21 pp. plus appendices.

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URS Corporation. 2014. 95% Design Report. Mississippi River Reintroduction into Maurepas Swamp project. Prepared for: State of Louisiana, Coastal Protection and Restoration Authority and U.S. Environmental Protection Agency. CPRA contract #2503-11-63. 149 pp plus appendices.

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Complex Project Coastal Wetlands Planning, Protection, and Restoration Act. U. S. Environmental Protection Agency, Region 6, Dallas, TX, Report WA #5-02. 14pp.

U.S. Environmental Protection Agency. 2001. Wetland Value Assessment Revised Project Information Sheet. Attachment G – In Diversion into Maurepas Swamps: Complex Project. Coastal Wetlands, Planning, Protection, and Restoration Act. U.S. Environmental Protection Agency, Region 6, Dallas, TX. Report WA #5-02. 58 pp.

U.S. Environmental Protection Agency. 2011. Draft Biological Assessment River Reintroduction into Maurepas Swamp (PO-29). Prepared for Section 7 Endangered Species Act consultation. U.S. Environmental Protection Agency, Region 6, Dallas, TX. 84 pp

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U.S. Fish and Wildlife Service. 2010. Biological Opinion. Memorandum to USACE CEMVN on effects of proposed Small Diversion at Convent/ Blind River Project on endangered pallid sturgeon (*Scaphirhynchus albus*). FWS Log No. 2010-F-2997. U.S. Fish and Wildlife Service, Lafayette, LA. 64 pp.