Report to Congress for Future Water Resources Development (WRRDA 7001) Submission Package

Proposal Name: Feasibility Study to formulate a Water Quality Monitoring Program in the Lower Mississippi River (LMR) and planning, engineering and design feasibility for eight conservation reach habitat areas.

Submission Date: 08/10/2017

Proposal ID Number: 1d2ca4da-389d-46bc-b5b8-a5e8f87c4c64

Purpose of Proposal: Feasibility Planning Study purpose directly ties to Aquatic Ecosystem Restoration wi th indirect benefits to Flood Risk Management and Navigation within the navigation channel of the LMR. The LMRRA report advanced 16 recommendations for expanding river management information, resource restoration and recreation enhancement options. Although TNC and LMRCC endorse all sixteen recomm endations, two recommendations included in the Final Assessment of the LMRRA are recommended for im plementation in this Feasibility Study: 1) Establish a Water Quality Monitoring Program in the LMR (Da ta Information Science and Communications Program, DISC 3) and 2) Conduct planning and design at the eight Conservation Reach Habitat Restoration Studies in the LMR for river restoration and explore recreat ion opportunities within the reaches (Habitat Restoration and Management Program, HRMP 1). This pro posal supports a study to evaluate the feasibility of establishing a water quality monitoring program in the LMR. A dedicated water quality monitoring program for the entire LMR would standardize procedures to wards building a long-term data set and aid in water quality assessments by regulatory agencies. The U.S. Geological Survey (USGS) and Environmental Protection Agency (EPA) would be the lead agencies, whil e the LMRCC, USACE, and other sponsors will assist in determining specifics of the monitoring program. Eight LMR conservation reach habitat restoration studies were identified in the LMRRA, which collectivel y represent 290 of the 954 river miles in the batture of the LMR. Study emphasis would include project pl anning, engineering and design within the main channel, secondary channels, floodplain lakes, and other ba ckwater areas within the LMR batture. This study will build from the work defined in Restoring America' s Greatest River and the Lower Mississippi River Resource Assessment.

1. Administrative Details

Proposal Name: Feasibility Study to formulate a Water Quality Monitoring Program in the Lower Mississippi River (LMR) and p lanning, engineering and design feasibility for eight conservation r each habitat areas.

by Agency: Lower Mississippi River Conservation Committee

Locations: AR,KY,LA,MO,MS,TN

Date Submitted: 08/10/2017

Confirmation Number: 1d2ca4da-389d-46bc-b5b8-a5e8f87c4c64

Supporting Documents

File Name	Date Uploaded
MS FWP ltr of support.pdf	08/10/2017
TNC supportltr.pdf	08/10/2017
RARG-FINAL-4-21-2015.pdf	08/10/2017
USFWS Ltr of support.pdf	08/10/2017
LMRRA Public Review Draft 2 (1).pdf	08/10/2017
LMR Conservation Plan Final USACE CIP 23 July 2013.pdf	08/10/2017
AGFC LMRRA support letter.pdf	08/10/2017
UMRBA letter supporting Lower Miss ecosystem feasibility study 8 8 2017.pdf	08/10/2017
Feasibility Study Letter of Support from LMRCC 8-9-17.pdf	08/10/2017
LMRRA Final Assessment Conservation Reaches Map.pdf	08/10/2017
Canalbargeltrofsup.pdf	08/10/2017
MO Letter of Support.pdf	08/10/2017
LMRLetter of Support TDEC.pdf	08/10/2017
CATLTRofSUPPORT.pdf	08/10/2017
LMRCC-WQ-FINAL-Sept2014.pdf	08/10/2017
LA DEQ ltr of support.pdf	08/10/2017
LockLevenlandownerLTRofSup.pdf	08/10/2017

2. Provide the name of the primary sponsor and all non-Federal interests that have contributed or are expected to contribute toward the non-Federal share of the proposed feasibility study or modification.

Sponsor	**Letter of Support**
The Nature Conservancy (Primary)	The Nature Conservancy is an active partner with the Co rps of Engineers on the Lower Mississippi River and aroun d the country. TNC was the lead cost share partner for t he Lower Mississippi River Resource Assessment, signed t he agreement, brought multiple partners together, and sec ured match for the study. The LMRRA report was deliv ered to Congress on July 18, 2016 and the cost share matc h exceeded our commitment by more than 25%. Delive ry of the LMRRA was a significant accomplishment for U SACE, TNC, LMRCC and other partners but it was only the first step to integrate restoration opportunities and in crease river understanding for Lower Mississippi River ma nagement. The essential next step is a feasibility plannin g study to establish the water quality-monitoring program and initiate programmatic restoration within priority loca tions of the LMR batture. Like the Comprehensive Mas terplan completed for the Upper Mississippi River, agencie s and partners must assess actions to balance the multiple uses of the LMR. Historically, flood risk management and navigation have been the focus of LMR river management. However, with numerous restoration demonstrations, river managers are documenting that ecological restoration can co-exist with other uses and in most cases, improve river c onditions for humans and native plants and animals. Th rough the feasibility planning study, water quality monito ring standards and criteria will be established to create th e implementation framework. A full assessment of the eig ht LMR priority conservation reaches will establish the hi ghest priority/opportunity projects and include detailed p lanning engineering and design. Subsequent restoration p rojects and recreation enhancement will be sequentially im plemented under a programmatic authorization for Lower Mississippi River restoration. The described process follo ws the successful model for project management from the UMRR program.

Lower Mississippi River Conservation Committee	The Lower Mississippi River Conservation Committee (L MRCC) is a 501 c 3 partnership of the six states on the Lo wer Mississippi River – Arkansas, Kentucky, Louisiana, M ississippi, Missouri and Tennessee. It is comprised of eac h state's natural resource conservation and environmental quality agencies. The LMRCC was formed in 1994 to pro vide a regional forum for collaboration and management o f the Lower Mississippi River. The states comprising the LMRCC are committed to collaborating to improve enviro nmental and recreational conditions on the river. We ha ve worked collaboratively with the U.S. Army Corps of E ngineers and the U.S. Fish and Wildlife Service since 2006 on rehabilitating secondary channels. Additionally, we w orked with The Nature Conservancy and other partners o n completing the Lower Mississippi River Resource Assess ment (LMRRA). The LMRRA provided a breadth of info rmation on needs related to river management, natural res ources and recreation. In order to begin to address the ne eds identified in the LMRRA, the projects identified here: 1) Establish a water quality monitoring program in the Lo wer Mississippi River and 2) Conduct eight conservation r each habitat restoration and recreation enhancement studi es on the Lower Mississippi River, are critical to furtherin g holistic management of the Lower Mississippi River. T he LMRCC supports this effort and is committed to this f easibility study.Further, each reach study will be conduct ed independently with USACE as the lead agency. Partici pating partners include USFWS, U.S. Dept. of Agricultur e, TNC, LMRCC, Mississippi River Trust, and potentially the Mississippi Interstate Cooperative Resource Associatio n (MICRA). LMRCC and TNC will work to bring multip le partners to increase the cost share dollars.

3. State if this proposal is for a feasibility study, a modification to an authorized USACE feasibility study or a modification to an authorized USACE project. If it is a proposal for a modification, provide the authorized water resources development feasibility study or project name.

[x] Feasibility Study

4. Clearly articulate the specific project purpose(s) of the proposed study or modification. Demonstrate that the proposal is related to USACE mission and authorities and specifically address why additional or new authorization is needed.

Feasibility Planning Study purpose directly ties to Aquatic Ecosystem Restoration with indirect benefits to Flood Risk Management and Navigation within the navigation channel of the LMR. The LMRRA report advanced 16 recommendations for expanding river management information, resource restoration and recre ation enhancement options. Although TNC and LMRCC endorse all sixteen recommendations, two recom mendations included in the Final Assessment of the LMRRA are recommended for implementation in this Feasibility Study: 1) Establish a Water Quality Monitoring Program in the LMR (Data Information Scien ce and Communications Program, DISC 3) and 2) Conduct planning and design at the eight Conservation Reach Habitat Restoration Studies in the LMR for river restoration and explore recreation opportunities w ithin the reaches (Habitat Restoration and Management Program, HRMP 1). This proposal supports a st udy to evaluate the feasibility of establishing a water quality monitoring program in the LMR. A dedicated water quality monitoring program for the entire LMR would standardize procedures towards building a lon g-term data set and aid in water quality assessments by regulatory agencies. The U.S. Geological Survey (USGS) and Environmental Protection Agency (EPA) would be the lead agencies, while the LMRCC, USA CE, and other sponsors will assist in determining specifics of the monitoring program. Eight LMR conserv ation reach habitat restoration studies were identified in the LMRRA, which collectively represent 290 of t he 954 river miles in the batture of the LMR. Study emphasis would include project planning, engineering and design within the main channel, secondary channels, floodplain lakes, and other backwater areas withi n the LMR batture. This study will build from the work defined in Restoring America's Greatest River a nd the Lower Mississippi River Resource Assessment.

5. To the extent practicable, provide an estimate of the total cost, and the Federal and non-Federal share of those costs, of the proposed study and, separately, an estimate of the cost of construction or modification.

	Federal	**Non-Federal**	**Total**
Study	$3,000,000	$1,050,000	$4,050,000
Construction	$50,000,000	$2,000,000	$52,000,000

Explanation (if necessary)

It is estimated that $750K of the total cost will be needed during the Feasibility Study to establish the par ameters, standards, and criteria of this large river water quality monitoring program. Multiple partners w ill support this work under the leadership of USGS and US EPA. At study completion, the estimated annu al cost to implement water quality monitoring is $2M. This figure may change due to the dynamic nature o f the LMR and length of the river. Remaining funding will accomplish a two-phased planning process for t he eight Conservation Habitat Reaches. First, a thorough expert review will be conducted to determine pr ioritized restoration needs and opportunities within this defined area. Projects identified as Tier 1 will be; 1) highest priority and 2) expected to be uncomplicated for implementation. They will likely include a com bination of restoration measures s in 1-3 areas selected to restore vital and diverse habitat to restore river f unctions and processes. Project development will include full scale planning, engineering and design in pre paration for implementation. Projects not identified as Tier 1 still represent the continual needs of river r estoration and will be further prioritized for project sequencing. These projects will receive high level plann ing, including an implementation timeline through a programmatic authorization. Cost estimates for this type of large river restoration are challenging, but flood risk management and navigation have necessitated that this work be addressed. The feasibility study will provide more definitive cost information, but a con tinual authority for river restoration with an annual appropriation of $50 M is needed to support a strong program to balance the ecological components of Lower Mississippi River with other river uses. Navigatio nal Servitude will define whether projects require cost share partners with the federal government.

6. To the extent practicable, describe the anticipated monetary and nonmonetary benefits of the proposal including benefits to the protection of human life and property; improvement to transportation; the national economy; the environment; or the national security interests of the United States.

Clean water is essential to aquatic native species that live in and along the LMR including federally endan gered species. Currently water quality data is almost non-existent. River managers and agencies need accu rate WQ data to assess and insure good water quality in the Mississippi River for multiple uses and reduce d downstream impacts to the Gulf. Scientist know excess nutrients from the basin negatively impact th e river and Gulf fisheries. Ongoing national conservation efforts attempt to reduce excess nutrients, and in clude wetland and floodplain restoration and reconnection practices. A water quality monitoring program is needed to document current conditions and practice effectiveness. The LMRRA recommends 8 conserva tion reach restoration studies. Reaches are spatially distributed throughout the lower 290 river miles, almo st 30% of the river, and range between 32 to 43 river miles. Studies would encompass both ecosystem resto ration and recreation enhancement. LMRCC's Restoring America's Greatest River (RAGR) initiative has i dentified 104 potential projects within these reaches. The LMR ecosystem is managed by the USACE to reduce flood risk and benefit commercial navigation. Management consequences include impacts to species and habitat diversity and complexity, and have reduced or eliminated hydrological connectivity between th e main channel and other aquatic habitats. Increasing river connectivity across batture floodplain provides better infiltration for regional groundwater, improves nutrient and sediment cycling and provides critical h abitat for fish, wildlife and birds. Improving ecological river conditions essentially restores natural river r esilience to provide services like groundwater infiltration, damping flood and drought extremes, process exc ess nutrients and a safer place for people to enjoy river recreation. The LMR Economic Profile (2014), fo und that the river tourism and outdoor recreation generates $16.8 B and provides 244,000 jobs/yr.

7. Does local support exist? If 'Yes', describe the local support for the proposal.

[x] Yes

Local Support Description

From the mayors along the Mississippi River to local landowners we have received strong support of this w ork and the work that went into the Lower Mississippi River Resource Assessment. The Mississippi Riv er Cities and Towns Initiative (MRCTI) have keyed into the work on recreation associated with the eight priorities reaches. From a local perspective, their interests are focused on increased recreational boat laun ches, Riverfront parks and landings, and improved ecological conditions that will bring more people to the river. Tourism is typically the number 1 or number 2 economic driver for these river communities so they are always looking for opportunities to improve these aspects of their cities. From landowners Erik Piaz za- Loch Leven Plantation and Troy Furr of Profit Island, 6000 acres and 2500 acres respectively both indi cate that they are interested in creating a sustainable and productive landscape for wildlife in harmony wit h the Mississippi River. They are striving to achieve a better solution whereby for their lands to be more resilient over time and more ecologically productive. That is why we support the Feasibility Study being proposed by The Nature Conservancy.

8. Does the primary sponsor named in (2.) above have the financial ability to provide for the required cost share?

[x] Yes

Additional Proposal Information

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MS FWP ltr of support.pdf

MISSISSIPPI
DEPARTMENT OF WILDLIFE, FISHERIES, AND PARKS

Sam Polles, Ph.D.
Executive Director

August 8, 2017

Ms. Lisa Kiefel
Planning and Policy Division
USACE – Headquarters
441 G St. N.W.
Washington, D.C. 20314

Dear Ms. Kiefel:

We support the Feasibility Study of initiating key recommendations from the Lower Mississippi River Resource Assessment to: 1) Establish a water quality monitoring program in the Lower Mississippi River and 2) Conduct eight conservation reach habitat restoration and recreation enhancement studies on the Lower Mississippi River. This reasonable step will assure the Lower Mississippi River continues to provide for people and the natural inhabitants of the river system.

The Lower Mississippi River is a great river that receives flow from the Upper Mississippi, Ohio, Missouri, Arkansas and Red rivers and guides that flow to the Gulf of Mexico. This river has experienced numerous great floods while also carrying $50 B worth of agricultural products to export markets each year. The river is the economic and cultural driver for the people who live along its banks.

The Lower Mississippi River Conservation Committee (LMRCC) has been working towards balanced river management since 1994. As a LMRCC member state, the Mississippi Department of Wildlife, Fisheries, and Parks, supports the work proposed in this feasibility study. The LMRCC water quality agencies produced a report in 2014 that detailed current water quality monitoring in the Lower Mississippi River and noted that a larger more concerted effort was needed. Additionally, the LMRCC has been conducting habitat restoration projects on the Lower Mississippi River since 2006 and has demonstrated these efforts can be complementary to traditional river management such as navigation and flood risk management.

There is an opportunity to move toward an improved Lower Mississippi River that serves our needs and provides essential river health for the diverse species that reside or migrate through the Lower Mississippi River. Building from past planning activities included in LMRCC's Restoring America's Greatest River plan and the Lower Mississippi River Resource Assessment, partners will prepare a Feasibility Study designed to implement priority restoration projects and establish sequencing for project implementation. At the same time, the fundamentals of establishing a water quality monitoring program will be addressed with an end-product that is ready for implementation. Water quality information is vital for managing the ecological health of the river but also provides valuable information for flood risk management and navigation.

1505 Eastover Drive • Jackson, Mississippi 39211-6374 • (601) 432-2142

We would like to add our voice to the many partners that believe the Lower Mississippi River can be managed for flood risk management and navigation, in addition to ecosystem restoration and recreation. Please give this proposal your full consideration.

Sincerely,

Sam Polles, PhD
Executive Director

1505 Eastover Drive • Jackson, Mississippi 39211-6374 • (601) 432-2142

Primary Sponsor Letter of Support

(As uploaded)

TNC supportltr.pdf

The Nature Conservancy
Louisiana

August 9, 2017

Ms. Lisa Kiefel
Planning and Policy Division
USACE – Headquarters
441 G St. N.W.
Washington, D.C. 20314

Dear Ms. Kiefel:

The Nature Conservancy (TNC), Louisiana and Mississippi Chapters support the Feasibility Study to initiating key recommendations from the Lower Mississippi River Resource Assessment to: 1) Establish a Water Quality Monitoring Program in the Lower Mississippi River and 2) Conduct eight conservation reach habitat restoration and recreation enhancement studies on the Lower Mississippi River. This reasonable step will assure the Lower Mississippi River continues to provide for people and the natural inhabitants of the river system. TNC is a 501 (c) 3 non-profit established in 1951 to conserve the lands and waters on which all life depends.

The Lower Mississippi River is a great river that receives flow from Upper Mississippi, Ohio, Missouri, Arkansas/Red Rivers and guides that flow to the Gulf of Mexico. This river has experienced numerous great floods while also carrying $50 B worth of agricultural products to export markets each year. The river is the economic and cultural driver for the people who are live along the banks.

For almost two centuries people have modified the river dynamics to cope with floods and keep navigation traffic moving along the most extensive inland waterway system in the world. These changes to river valley were necessary but over time they degrade the natural forests, wetlands, channels, oxbows and bayous vital for plants, animals, fish that historically thrived within the river. Today, we better understand the interactions between what people need to live with the river and how to balance those uses with the needs of a natural river system.

There is an opportunity to move toward an improved Lower Mississippi River that serves our needs and provides essential river health for the diverse species that reside or migrate through the Lower Mississippi River. Building from past planning activities included in Restoring America's Greatest River plan and the Lower Mississippi River Resource Assessment, partners will prepare a Feasibility Study designed to implement priority restoration projects and establish sequencing for the projects that should follow. At the same time, the fundamentals of establishing a Water Quality Monitoring program will be addressed with an end-product that is ready for implementation. Water quality information is vital for managing the ecological health of the river but also provides valuable information for flood risk management and navigation.

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Our partnership brought the Lower Mississippi River Resource Assessment to completion and we want to continue our commitment to the Lower Mississippi River. Moving forward with LMR Feasibility Study will insure aquatic ecosystem restoration will be included in the USACE focus along with flood risk management and navigation to promote balanced uses of the vital river resources. Please give this proposal your full consideration.

Sincerely,

Keith Ouchley
State Director, Louisiana and Mississippi

Additional Proposal Information

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RARG-FINAL-4-21-2015.pdf

RESTORING AMERICA'S GREATEST RIVER

A HABITAT RESTORATION PLAN FOR THE LOWER MISSISSIPPI RIVER

LOWER MISSISSIPPI RIVER CONSERVATION COMMITTEE

CONTENTS

Mission: Promote the protection, restoration, enhancement, understanding, awareness and wise use of the natural resources of the Lower Mississippi River, through coordinated and cooperative efforts involving research, planning, management, information sharing, public education and advocacy.

The cover photo, taken by Bruce Reid near Fitler, Mississippi, shows the Mississippi River main channel, a sandbar, a notched dike and the batture forest.

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INTRODUCTION

The Lower Mississippi River Conservation Committee (LMRCC) was founded in 1994 and is a coalition of 12 state natural resource conservation and environmental quality agencies from Arkansas, Kentucky, Louisiana, Mississippi, Missouri and Tennessee. The LMRCC Executive Committee has one member from each of the agencies. There are also five federal partners: U.S. Army Corps of Engineers (USACE), Natural Resources Conservation Service (NRCS), U.S. Environmental Protection Agency (EPA), U.S. Fish and Wildlife Service (USFWS) and U.S. Geological Survey (USGS). The USFWS provides a coordination office. LMRCC staff work out of the USFWS's Lower Mississippi River Fish and Wildlife Conservation Office in Jackson, Mississippi.

The LMRCC provides the only regional forum dedicated to conserving the natural resources of the Lower Mississippi River (LMR) and its floodplain. The focus of the LMRCC is habitat restoration, long-term conservation planning and nature-based economic development.

The purpose of this document is to synthesize the landscape-level planning efforts of the LMRCC. It begins with background information on the LMR system, including habitats and species, and concludes with planning efforts, accomplishments to date and recommendations for future direction.

The Mississippi River has a drainage basin of 1.225 million square miles and encompasses 41% of the contiguous United States and parts of two Canadian provinces (Baker et al. 1991). The river's main stem extends 2,348 miles from the headwaters at Lake Itasca in northern Minnesota to the most downstream portion at Head of Passes, Louisiana. The Upper Mississippi River is the portion above Cairo, Illinois, and is mostly impounded by 27 locks and dams. Between the mouths of the Missouri River at St. Louis and the Ohio River at Cairo, is a 200-mile, unimpounded reach often referred to as the Middle Mississippi River, although it is part of the upper river. The LMR begins at the Ohio River confluence at Cairo and flows 953.5 miles to the Gulf of Mexico (USACE 2013, USFWS 2013a).

MISSISSIPPI RIVER WATERSHED

The Lower Mississippi River Valley lies within the central Gulf Coastal Plain physiographic province (Baker et al. 1991, USACE 2013). The valley varies in width between 40 and 110 miles and includes parts of Missouri, Illinois, Kentucky, Tennessee, Arkansas, Mississippi and Louisiana. The size of the LMR leveed floodplain (i.e., batture) is unclear because estimates vary. For example, the National Land Cover Database (NLCD 2011) indicates that the batture is 2.1 million acres; Baker et al. (1991) lists nearly 1.5 million acres; and the USACE's 2011 post-flood report (MR&T 2012) has it at 2.8 million acres.

Regardless of this discrepancy, the floodplain has been reduced by 80% through the construction of the levee system (Baker et al. 1991).

RIVER MODIFICATIONS

After the 1927 flood, the Mississippi River and Tributaries (MR&T) Project was authorized by the Flood Risk Management Act of 1928, which has been modified several times. The MR&T Project includes a 2,216-mile levee system, three floodways to divert excess flows past critical reaches, and channel modifications and stabilization features. The Channel Improvement Program (CIP) of the MR&T Project provides for a low-water navigation channel from Cairo, Illinois, to Baton Rouge, Louisiana, that is at least 9 feet deep (authorized to 12 feet) and 300 feet wide (USACE 2013, USFWS 2013a).

Refugees of the 1927 flood took to higher ground in Vicksburg. Photo: National Weather Service

Another impact during the past 30 years has been a gradual but substantial loss of secondary channels and the area of seasonally flooded in-channel habitats. Approximately 23 secondary channels totaling nearly 10,000 acres have been lost in the LMR since the 1960s due to natural realignments and/or channel modifications, including closure dikes, as a result of the MR&T Project (Williams and Clouse 2003). Ninety-two LMR secondary channels remained in the 1990s.

Articulated concrete mattress (above) is used to stabilize banks along the Lower Mississippi River. Photo: Bruce Reid

Three main types of river training structures are used in the CIP: revetments (to prevent bank erosion, protect levees and maintain channel alignment), dikes (to promote a self-maintaining navigation channel) and bendway weirs (to widen narrow bends for navigation). Alternative structures are also used, including: hard points (functioning as revetment), roundpoints and chevron dikes ('U'-shaped structures constructed of riprap that function similar to dikes). A combination of these structures works synergistically to achieve navigation objectives.

For more than a century, revetments have been used on the Mississippi River to deter bank caving, protect levees and other structures, and to maintain an efficient channel alignment. As of 2012, there were 1,055 miles of revetment (e.g., articulated concrete mattress (ACM and riprap) along the banks of the LMR (USACE 2013).

Beginning in the 1960s, a comprehensive dike construction program was initiated to reduce dredging costs and enhance navigation

alignments. Stone dikes (e.g.,riprap) are constructed in the river channel to develop a self-maintaining (minimal maintenance dredging), low-water navigation channel (USFWS 2013a).

However, sediment can accrete downstream of dikes, creating sand bars and reducing the river's depth and width. Dikes can also disconnect secondary channels and the floodplain from the river, thus degrading the natural hydrology.

The USACE began a dike-notching program on the LMR in the late 1980s to reduce sedimentation in the dike fields. Notching closure dikes of secondary channels is effective in diversifying habitat by maintaining flows through secondary channels for extended periods, particularly during low-river stages. A total of 774 dikes have been constructed between river miles 212 and 953.5, and 29% of them have been notched to diversify habitat (USACE 2013, USFWS 2013a).

Bendway weirs are linear stone structures, similar to transverse stone dikes, except they are constructed from the concave bank across the main or navigation channel. A series of weirs are constructed in a bend. These structures typically have elevations 20 feet or more below the Low Water Reference Plane, allowing navigation traffic above the structures (USFWS 2013a).

Dredging is another tool used to maintain the navigation channel. Dredging primarily occurs at crossings (i.e., where the main current crosses

Nearly 30% of the 774 rock dikes (above) along the Lower Mississippi River have been notched (below) to allow for more consistent water flows to secondary channels and to diversify aquatic habitat.

Photos: Bruce Reid and Angeline Rodgers

from one bank to the other), of which there are approximately 200 between the mouth of the Ohio River and Baton Rouge, Louisiana (Baker et al. 1991). Over the past 10 years, nearly 431 million cubic yards of sediment have been dredged from the main channel of the Mississippi River, including the deep draft channel below Baton Rouge (USACE 2013).

Meander cutoffs are an example of a historic modification used in the early to mid-1900s. In an effort to create a shorter and straighter river channel to increase discharge capacity and shorten navigation distance, engineers increased cutoff formation in the LMR (Baker et al. 1991). The meander cutoff program of the USACE in the 1930s and 1940s was initiated following the 1927 flood and potentially resulted in the greatest impact that altered reaches of the LMR from sinuous to straight (Schumm 2005).

Most of the 16 cutoffs that occurred in the LMR from 1929 to 1942 were constructed by the USACE and shortened the river by 152 miles (16%) (Baker et al. 1991). Schumm (2005) noted that the river was also shortened by 55 miles through chute development. Cutoffs made in a 340-mile reach of the LMR from near Memphis, Tennessee, to near Natchez, Mississippi, resulted in degradation upstream and deposition downstream (Schumm 2005). Cutoffs result in greater current velocity which results in bed and bank erosion (Baker et al. 1991). Schumm (2005) noted that flood peaks were reduced as designed, but channel stability decreased.

HABITATS AND LAND USE

Although the floodplain and backwater areas have been dramatically altered, the existing leveed floodplain, in many locations, continues to function as a dynamic freshwater ecosystem that can change in response to the river's annual hydrologic regime. The batture contains a diversity of habitats, including oxbow lakes, meander scars, borrow pits, wetlands and tributary mouths (Baker et al. 1991).

The 2.1 million-acre LMR floodplain comprises the following land uses:

Floodplain Land Use	Acreage
Woody wetlands	963,131
Open water	532,289
Farmland	419,160
Emergent herbaceous wetlands	53,598
Forest	44,466
Barren land	29,496
Grassland	8,065
Shrub/scrub	6,862
Developed land	56

Source: National Land Cover Database, 2011

There are also four backwater areas outside the batture that are hydrologically connected to the LMR: New Madrid Floodway, White River basin, Yazoo River basin, and Lower Red River basin, totaling 680,800 acres (MR&T 2012).

There have been several aquatic habitat classifications of the LMR. Nine macrohabitats were defined for the channel environment that can be easily

Forested wetlands cover large areas of the Lower Mississippi River floodplain and backwater areas. Photo: Bruce Reid

identified and include: 1) steep sandbar, 2) gentle sandbar, 3) island complex, 4) ACM/riprap, 5) natural bank, 6) flooded shoreline, 7) gravel bar, 8) channel and 9) dike (Miranda and Killgore 2011):

Steep sandbar: High sloping sandbar often associated with the downstream reach of an island or point bar where maximum current speeds begin to cross the channel, forming eddies, deep water and depositional areas along the bank.

Gentle sandbar: Low sloping sandbar with moderate to high current. They constitute the primary littoral habitat in the river and occur in association with point bars, islands, middle bars and dike systems.

Island complex: Usually include, from the bank outward, a secondary channel, island and main channel. Upper reach is shallow and swift while lower reaches become deeper and sluggish.

ACM/riprap: ACM is placed over eroding river banks with riprap along the top portion. Buckling and variation in bottom slopes create large interstitial spaces surrounded by hard substrates. Strong currents and deep water are usually associated with this habitat.

Natural bank: Usually occurs on the concave side of the river where consolidated silts and clays form the primary substrate. Banks are often steep and woody debris from fallen trees can accumulate.

Flooded shoreline: At high river stages, flooded sandbars and willow trees provide temporary habitats usually occurring along the convex side of the river. Detritus and terrestrial vegetation become available as relatively shallow, low-velocity refugia for a variety of fish species.

Gravel bar: Coarse sand and gravel are deposited in bendways, usually in the upper reaches of point bars or islands where water is shallow and swift. Gravel may extend from the shoreline to the channel border.

Channel: Includes the main channel and channel border. Water depth can exceed 82 feet. Currents are strong and substrate is usually sand.

Dike: Constructed with large rocks (i.e., riprap) and extends perpendicularly from the bank to the channel border habitat. Some dikes can exceed 2,953 feet in length. Large eddies can form below dikes, and depth and velocity vary greatly along its longitudinal axis. Sand deposition is common below dikes.

Photo: Jan Hoover

Vegetated islands are valuable habitats within the Lower Mississippi River floodplain (Jack Killgore, pers. comm.). Because they are relatively stable, they provide shoreline habitats for littoral fishes and help maintain bathymetric complexity in secondary channels after floods. They also contribute woody debris to the aquatic system, which is used by a variety of organisms as feeding and spawning areas and as refugia from predators. Most major gravel bars occur at the upstream reaches of vegetated islands. At low river stages, the only available backwater habitat connected to the river is at the lower reach of the secondary channel of vegetated islands. The relatively high, steep sloping shorelines of vegetated islands maintain scour pools. These pools support large numbers of fish and other aquatic fauna attempting to escape faster flows in the main channel.

FLOODPLAINS

Floodplains are terrestrial areas adjacent to a river. They become inundated during high-water events and provide seasonal, unrestricted low-flow, backwater conditions. Natural fluvial processes such as lateral and vertical erosion and channel migration and abandonment create a variety of floodplain habitats (e.g., side channels, backwaters, isolated channels, oxbows, ponds, and marshes) (Amoros and Bornette 2002).

The extent, duration and timing of flooding provide a diversity of hydrologic connections that are vital for the ecosystem. Floods homogenize the floodplain and provide connectivity that allows fish movement between the river and floodplain, affecting fish assemblages (Miranda 2005). Dembkowski and Miranda (2011) noted that lateral connectivity is essential for providing fish life history needs and providing other lotic ecosystem services. Floodplain habitats are used by many river species for spawning and nursery areas (Baker et al. 1991) and for feeding and shelter (Miranda et al. 2013). Floodplain connectivity is also important for aquatic insects, mussels, turtles, birds and mammals (Winemiller 2003).

One of the most significant features affecting the natural resources is the loss of connectivity between the historic floodplain and the Mississippi River. Winemiller (2003) noted that levees eliminate connectivity between rivers and floodplains and prohibit the exchange of water, materials and organisms. This impairs nutrient cycling, productivity and biodiversity and diminishes habitats crucial for completion of many species' life cycles.

Virtually no new habitat is being created, while existing floodplain lakes and secondary channels are gradually being lost due to sedimentation (Williams and Clouse 2003). Modification of the flood pulse, channelization, dredging, levee construction and embankments all inhibit lateral erosion and other natural river dynamics (Amoros and Bornette 2002).

Habitat loss, a reduction in the flood-pulse and reduced connectivity may be contributing factors to poor recruitment by some fishes (Barko et al. 2006). Access between various habitats (e.g., to spawning and nursery areas) are critical for fish recruitment and sustainability of fish populations (Amoros and Bornette 2002). Enhancing floodplain connectivity will provide refugia for young fishes during floods and should be a high priority (Barko et al. 2006).

Alligator Gar (above) spawn in the Lower Mississippi River floodplain. Photo: U.S. Fish and Wildlife Service

The Lower Mississippi River floodplain provides important nesting and feeding habitat for Snowy Egrets (right) and other wading birds.

Photo: Bruce Reid

Some of the mysteries of the Lower Mississippi River floodplain are still being explored. U.S. Army Corps of Engineers biologist Jan Hoover has collected large numbers of invertebrates in borrow pits near Vicksburg, Mississippi (Jan Hoover, pers. comm.). Two species collected inhabit temporary pools and can remain dormant for years during dry periods. One species of Clam Shrimp, thought to be of the genus *Eulimnadia*, is still being identified with the help of a biologist at the University of Akron in Ohio. Hoover and students Tyler Strange and Heather Smith also found a species of Fairy Shrimp, *Streptocephalus seali*, that is widespread from Canada to Mexico.

U.S. Army Corps of Engineers biologist Jan Hoover (above) retrieves a trap used for collecting invertebrates such as the Fairy Shrimp (below left), *Streptocephalus seali,* and a Clam Shrimp (below right) thought to be of the genus *Eulimnadia*. Photos: U.S. Army Corps of Engineers

Populations of Black Bears, including the threatened subspecies Louisiana Black Bear, are expanding along the Lower Mississippi River. The heavily forested active floodplain provides important habitat. Photo: Brad Young

SPECIES OF CONCERN

PALLID STURGEON, *Scaphirhynchus albus*

Since the USFWS listed the Pallid Sturgeon as endangered in 1990, the status of the species has improved and is considered stable. New information has allowed managers to gain a better understanding of the species in the Lower and Middle Mississippi River; however, rangewide data regarding recruitment, mortality, habitat use and abundance remain limited. (USFWS 2013c).

The Coastal Plain Management Unit (CPMU) for the species consists of the entire LMR from the confluence of the Ohio River at Cairo, Illinois, to the Gulf of Mexico, and includes the Atchafalaya River distributary system in Louisiana (USFWS 2013c). When the Pallid Sturgeon was listed, only 28 historical records were documented from the CPMU. Since 2000, more than 1,100 Pallid Sturgeon have been captured in the CPMU (more than 500 from the LMR, and more than 600 from the Atchafalaya River) (Killgore et al. 2007, USFWS database 2013), exceeding wild Pallid Sturgeon capture numbers from all other management units combined.

Although Pallid Sturgeon population size in the LMR has not been quantified, available data suggest a substantial population when compared to fishing effort and fish species composition (USFWS 2013a). Killgore et al. (2007) found that Pallid Sturgeon comprised 2.2% of fish captured on winter-set trotlines, and ranked fifth in relative abundance out of 22 species collected. During two years of trotline sampling at Vicksburg and Tunica, Mississippi, Pallid Sturgeon comprised 2.4 and 2.5%, respectively, of fish collected at both locations, and ranked fourth in relative abundance out of 11 species collected (Aycock et al. 2012).

Telemetry studies have shown that larger Pallid Sturgeon consistently

Mississippi Department of Wildlife, Fisheries and Parks biologists with a tagged Pallid Sturgeon before release. Paul Hartfield (left) and Angeline Rodgers track tagged sturgeon.
Photos: Mississippi Department of Wildlife, Fisheries and Parks and Bruce Reid

use multiple channel habitats such as point bars, secondary channels, crossovers, island tips, natural banks, and river engineering structures such as dikes and reveted banks (Kroboth et al. 2013).

According to the Revised Recovery Plan (USFWS 2013c), the range-wide limiting factors for Pallid Sturgeon include: "1) activities which affect connectivity and the natural form, function and hydrologic processes of rivers; 2) illegal harvest; 3) impaired water quality and quantity; 4) entrainment in water diversion structures; and 5) life history attributes of the species (i.e., delayed sexual maturity, females not spawning every year, and larval drift requirements)."

Shovelnose Sturgeon appear similar to Pallid Sturgeon. Photo: Bruce Reid

Commercial harvest of sturgeon for caviar and smoked flesh has occurred to various degrees in the LMR since the 1800s. Harvest for Shovelnose Sturgeon has been closed for at least three decades in the Arkansas, Mississippi and Louisiana reaches of the LMR south of the Tennessee state line. However, harvest of Shovelnose Sturgeon for caviar had increased in reaches of Tennessee, Kentucky, Missouri and Illinois. Based on data that indicated significant numbers of mature female Pallid Sturgeon were being taken during harvest of Shovelnose Sturgeon in the Tennessee (Bettoli et al. 2009), and high mortality of pallids in reaches where commercial harvesting was still legal (Killgore et al. 2007), the USFWS listed the Shovelnose Sturgeon within the sympatric range of Pallid Sturgeon as threatened due to similarity of appearance (USFWS 2010a). This action, coupled with state regulations, has effectively eliminated commercial harvest of sturgeon in the LMR.

INTERIOR LEAST TERN, *Sterna antillarum*

The interior population of the Least Tern was listed as endangered by the USFWS in 1985. At the time the recovery plan was developed (USFWS 1990), there were an estimated 5,000 Interior Least Terns distributed throughout the Interior Basin. The recovery plan outlined recovery strategies to increase the population to approximately 7,000 birds (USFWS 1990).

Substantial new information now exists concerning the species' distribution, density, population dynamics, natural history, habitat quantity and quality, and threat levels. Data indicate the population has increased significantly throughout its range and reached the recovery criteria of 7,000 birds. Range-wide population counts were 722 in 1984, 8,859 in 1995 and 17,591 in 2006. Most of the increase has occurred on the LMR (USFWS 2013b).

Nesting colonies in the LMR have been monitored yearly since 1985. Terns are currently distributed along an 800-mile reach between the confluence of the Ohio River and Baton Rouge, Louisiana. The LMR population level has ranged from 8,000-18,000 birds over the past nine years, and the drainage basin recovery goal (2,500) has been exceeded for more than 20 years. Some proportion of the increase in adult tern numbers has been attributed to improved survey efforts and efficiency (Lott 2006). For example, changes in survey methods utilized in the LMR and extending survey reaches correspond to some degree with higher counts. However, the large numbers of terns within the LMR unimpounded navigation system has also been attributed to higher elevation sand and gravel bars associated with the construction of channel training dikes (Lott and Wiley 2012, Lott et al. 2013).

In the LMR, tern nesting colonies are typically located on an unattached (surrounded by water) sand and/or gravel bar usually associated with

a dike field and secondary channel. Those colonies that occur on sand or gravel bars connected with the bank are on very large, remote point bars, ½ to 1 mile wide and often 2 to 4 miles long (Jones 2012). USACE analyses indicate that habitat quantity has remained relatively stable and underutilized by nesting terns for the past two decades (USACE 2008, USACE 2013) and habitat quantity and quality does not appear to be a limiting factor for the species in the LMR. Based upon improvements in range-wide status and successful protection and management of its habitats, the USFWS has recommended delisting the Interior Least Tern due to recovery (USFWS 2013b).

Interior Least Tern nests (above) are shallow depressions in the sand.

Photo: U.S. Fish and Wildlife Service

FAT POCKETBOOK, *Potamilus capax*

Threats to endangered Fat Pocketbook mussel include habitat modification and loss, population fragmentation caused by dams, and channelization related to navigation and flood control. Fragmentation of suitable habitat and range make local populations susceptible to threats such as droughts, point- and non-point source pollution, and land-use changes in their respective watersheds. Federal and state laws protecting the mussel have reduced threats to the species. Studies indicate that populations may be self-sustaining at low densities. Fat Pocketbook mussels have recently been found in the LMR (USFWS 2009).

There are no historical records of the species from, or adjacent to, the LMR channel. Most recent LMR collection records are from secondary channels along the river (USFWS 2012), and the expansion of the species' range into the LMR appears to be related to more stable habitat conditions created within USACE dike fields associated with secondary channels. Live and fresh-dead specimens have been collected from secondary channels between River Miles 410 and 800 that are stabilized by dike fields and maintain hydrologic connectivity with the main channel. A single young individual has been collected in a trawl sample below a chevron dike, in Bolivar County, Mississippi (W.T. Slack, USACE-ERDC pers. comm.). Recent collections from the LMR indicate a widespread population, but more sampling is needed to assess abundance and trends.

LOUISIANA BLACK BEAR, *Ursus americanus luteolus*

The range of the Louisiana Black Bear, a subspecies listed as threatened by the USFWS, includes portions of the Lower Mississippi River floodplain in southern Mississippi and eastern Louisiana. The lower river's active floodplain, or batture, is considered a priority conservation area for the Louisiana Black Bear, as are portions of the Atchafalaya River basin, a major distributary. Reforestation of the batture will expand travel corridors and provide important links to national wildlife refuges and other public lands (USFWS 2014b).

The Louisiana Black Bear occurs at numerous national wildlife refuges throughout its range, including two within the batture: St. Catherine Creek National Wildlife Refuge near Natchez, Mississippi, and Cat Island National Wildlife Refuge near St. Francisville, Louisiana. Several studies suggest that Black Bears at White River National Wildlife Refuge in eastern Arkansas are genetically similar to Louisiana Black Bear populations to the south, but those studies have not led to the protection of the Arkansas population under the Endangered Species Act (USFWS 2014b).

Populations are thought to be growing in the Tensas and Atchafalaya river basins. Two new breeding populations are in east-central Louisiana and western Mississippi (USFWS 2014b).

NATIVE FISHES

Baker et al. (1991) noted that there were at least 91 species of freshwater fishes living in the Lower Mississippi River and that other studies suggested there were as many as 121 species.

Commercial species include Channel, Flathead, and Blue catfish; three species of buffalo; and Freshwater Drum. Primary sport fish species include crappies, black bass, White Bass, sunfish, temperate bass and catfish.

Because different fish species have specific habitat requirements for their various life stages, diversifying habitat will greatly benefit the fish community.

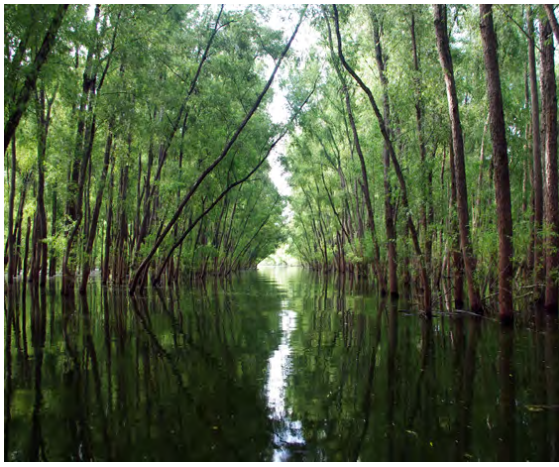
White Bass are popular sport fish.

Photo: Paul Ingram

Habitat alterations, decreased connectivity and diminished water quality have affected fish communities. Crites et al. (2012) hypothesized that low dissolved oxygen concentrations contributed to the presence of few predatory, sport or commercial fish species in an isolated chute of the Middle Mississippi River. Connectivity is significant in determining fish assemblages in floodplain lakes (Dembkowski and Miranda 2011). They hypothesized that the periodic connection and the associated habitat heterogeneity that it provides are important for maintaining fish species richness and diversity in large-river floodplain lakes. Miranda (2005) noted that oxbow lakes with greater connectivity supported more species that require flow or flooding (e.g., Skipjack Herring, River Carpsucker, gars and White Bass). Conversely, oxbows with limited or no hydrological connection with the river supported species that prefer low-flow conditions (e.g., sunfish, Yellow Bass and shad species). Miyazono et al. (2010) noted that species richness of periodic strategists (e.g., riverine species) was positively correlated with connectivity.

Periodic connection to the river (right) is important for maintaining fish species richness and diversity in floodplain lakes. A fly fisherman (below) takes advantage of swift currents through a notched dike.

Photos: Bruce Reid and Tommy Shropshire



CLIMATE ADAPTATION

Over the past 30 years, scientists and managers have documented reductions in local species abundance and richness likely attributable to climate change. Ecological studies and monitoring have documented changes in phenology, distribution, physiology, behavior, survival, reproduction, community composition and nutrient cycling. Meteorologists have documented increasing frequency and intensity of extreme weather events such as hurricanes, floods and droughts. These trends are expected to continue, if not to accelerate (IPCC 2013; The White House 2014; Stein et. al. 2014; USFWS 2014a; Marino et. al. 2014; Johnson 2014).

Climate change imposes unprecedented new challenges and management problems that cannot be solved without a fundamental change in the way we approach conservation. Adaptation strategies are adjustments in natural or human systems to minimize the harmful impact of climate change. The LMRCC has included adaptation strategies (Stein et. al. 2014) into existing planning and implemented actions that provide climate change benefits. For example, one of the main adaptive strategies is enhancing floodplain connectivity that leads to protection and restoration of refugia, another adaptive strategy (Stein et. al., 2014; Heller and Zavaleta 2009). Refugia may provide habitats that are well distributed, replicated and connected in order for their resident species to have enough time to adapt to the changing conditions.

Efforts to develop and fund monitoring programs for water quality and fish populations are also particularly important for adaptation. A crucial element of "climate smart conservation" (Stein et. al. 2014) is documenting climate-related changes to habitat quality and short- and long-term changes in the composition of native and non-native species. Understanding species' responses will inform management needs.

Given that understanding climate change is an ongoing process, cooperation with the scientific community is an adaptive strategy (Heller and Zavaleta, 2009). Numerous ongoing and planned projects provide information for establishing a baseline and a potential climate change vulnerability assessment (Johnson 2014).

The LMRCC's wetland and forest restoration efforts support climate adaptation.

The Lower Mississippi River Batture Reforestation Project provides adaptive benefits from ecosystem restoration (Stein et. al. 2014; Heller and Zavaleta 2009). Relatively intact systems tend to respond better to disturbances. The significance of restoration is especially apparent in the context of wetlands in the batture, because wetlands are adaptation mechanisms themselves, providing flood control and water purification. Climate change can also be addressed through other means (e.g., carbon capturing and sequestration and emission reduction from power plants, factories, and vehicles). One of the most cost-effective options is carbon sequestration through photosynthesis in terrestrial sinks (USFWS 2014a). Therefore, the LMRCC's wetland and forest restoration efforts support climate adaptation.

Engagement is a third component of the climate change framework (USFWS 2010b). Engagement refers to providing leadership through cooperation, or building partnerships across local, state and federal agencies and non-government organizations. The LMRCC's success depends on the cooperative efforts of its institutional members.

Lower Mississippi River Batture Reforestation Project

The NRCS has identified the Mississippi River basin as a top priority because of water quality concerns (i.e., nutrient loading), and implemented the Mississippi River Basin Healthy Watersheds Initiative (MRBI). As part of the MRBI, the Lower Mississippi River Batture Reforestation Project was initiated in 2012 to restore wetlands and forests within the lower river's active floodplain, or batture. The LMRCC, the nonprofit Mississippi River Trust and the NRCS work together to identify flood-prone cleared land that landowners desire to reforest through Wetland Reserve Easements. Funding is provided by the NRCS, along with the Walton Family Foundation and the U.S. Endowment for Forestry and Communities. By late 2014, 58 properties covering 12,059 acres had been enrolled in the program.

Reforestation of the batture will help:

- Lessen the amount of excess nutrients (i.e., nitrogen and phosphorus) and various pesticides entering the river and the Gulf of Mexico.
- Reduce flooding of farmland.
- Reduce financial demand for disaster assistance and crop insurance on lands with repeated losses.
- Increase opportunities for outdoor recreation such as hunting, fishing and wildlife viewing.
- Expand habitat for bears, waterfowl, other migratory birds and other wildlife.

Workers (above) plant a 400-acre batture tract near Clarksdale, Mississippi. NRCS scientist Rachel Stout-Evans (right) tests soil to determine proper tree species for planting. The historic 2011 flood on the Lower Mississippi River caused widespread erosion of cleared land (below) in the batture. The flood also deposited large amounts of sand on some batture cropland.

Photos: Bruce Reid

PLANNING

In 2000, the LMRCC completed its Aquatic Resources Management Plan (LMRCC 2000). The plan outlines strategies for restoring aquatic resources within the river's active floodplain from the confluence of the Mississippi and Ohio rivers at Cairo, Illinois, to the Gulf of Mexico.

Goals of the plan are to:

- Maintain or improve aquatic habitat quantity, quality and diversity in the Lower Mississippi River ecosystem.
- Improve water quality in the Lower Mississippi River by implementing the Clean Water Act.
- Restore, conserve and manage the biological diversity of native fishes and invertebrates and provide for sustainable harvest of selected fish species in the Lower Mississippi River ecosystem.
- Improve economic opportunities in river-side communities through the sustainable use of environmental resources.
- Ensure coordinated management of the Lower Mississippi River ecosystem through involvement of management agencies, resource user groups and commercial interests in planning and implementing management activities.
- Increase public use and awareness of fisheries resources in the Lower Mississippi River ecosystem .

The Mississippi River Conservation Initiative was the implementation phase of the Aquatic Resources Management Plan. From 2001-2004, the LMRCC held meetings in the six member states to identify projects to improve aquatic habitat and enhance public access to the river environment. Through the meetings, 239 restoration projects were identified.

The restoration work of the LMRCC was coined "Restoring America's Greatest River" and is based on a unique partnership between the LMRCC, the USACE and the USFWS. The focus of these proposed projects is to enhance LMR habitats and restore floodplain hydrology and connectivity when landowners are interested and opportunities exist.

Secondary channels with dike fields are priority restoration sites.

Photo: Bruce Reid

To better focus LMRCC restoration efforts, a ranking system for proposed secondary channel enhancement work was completed by the USACE Engineer Research and Development Center (ERDC). Scientists established a Habitat Quality Index and Economy of Restoration Index that were combined into a Priority Index (Killgore et al. 2012). Projects were ranked according to improvements to habitat quality and cost-effectiveness.

This ranking system is used to guide the selection of future restoration projects for secondary channels. The projects will benefit protected species such as the Pallid Sturgeon, Interior Least Tern and Fat Pocketbook mussel, in addition to other native species.

During the past several years, the LMRCC has been a partner in the Lower Mississippi River Resource Assessment (LMRRA), the region's first comprehensive natural resources study since the Lower Mississippi Region Comprehensive Study in 1974.

The LMRRA will identify information needed for river-related management, natural resource habitat needs, and river-related recreation and access needs. The project area includes the entire LMR, the Atchafalaya River and portions of some navigable tributaries. This project assesses available information and will make recommendations for improvement. A report will be delivered to Congress in 2015. Partners include the USACE districts in Memphis, Vicksburg and New Orleans; the LMRCC; The Nature Conservancy; National Audubon Society; Mississippi River Corridor-Tennessee; Wildlife Mississippi; Delta Wildlife; and Quapaw Canoe Company. The LMRRA incorporates habitat restoration needs identified by the LMRCC's planning efforts and was the impetus for the revised Restoring America's Greatest River plan.

Jason Dickard of the U.S. Army Corps of Engineers discusses the Lower Mississippi River Resource Assessment at the 2014 LMRCC annual meeting. Gretchen Benjamin (left) of The Nature Conservancy is a primary partner.

Photo: Bruce Reid

This plan, Restoring America's Greatest River: A Habitat Restoration Plan for the Lower Mississippi River, is not intended to replace the Aquatic Resources Management Plan (LMRCC 2000) but to build upon it. The new plan includes and combines information from the Aquatic Resources Management Plan, Mississippi River Conservation Initiative and the original 239 proposed projects into one document. The focus of this plan is habitat-driven, which will benefit native species that live in and along the LMR and the people who enjoy the river. Development and implementation of this plan are critical for the restoration of the LMR and its batture.

The former list of 239 proposed projects has been reviewed and updated. It now includes a list of 253 habitat restoration and access enhancement projects (Appendix A). Each of the proposed projects has been placed into one of eight project focus categories.

Current Project Focus Categories

- Create, rehabilitate and diversify secondary channels
- Restore and diversify floodplain water bodies
- Augment aquatic connectivity with the floodplain
- Tributary enhancement
- Create/rehabilitate wetlands
- Enhance main channel habitat diversity
- Enhance terrestrial habitat
- Improve recreational access

The USACE's Andy Simmerman and the LMRCC's Angeline Rodgers discuss a dike-notching project.

Photo: LMRCC

ACCOMPLISHMENTS

Implementation of the Restoring America's Greatest River plan began in 2006. To date, the focus has been on rehabilitating secondary channels. Dikes and closure dikes are notched to provide more permanent flow between productive secondary channels and the main channel and to create new secondary channels through existing dike fields. Implementation of these projects has relied on a partnership among the USACE, LMRCC and USFWS, with assistance from Mississippi River Trust. The USACE provides engineering design and determines placement of notches to ensure dike integrity. The USACE also provides construction inspection. The LMRCC acquires all necessary permits, hires the construction contractor, and coordinates the project planning and implementation. The USFWS provides the construction funding through the National Fish Passage Program and staff. Mississippi River Trust also provides funding. To date, 14 projects have been completed, restoring more than 56 miles of channel habitat and thousands of surrounding acres.

Completed Project	River Miles	State	USACE District	Year Built	Miles of Side Channel
Island 63	640.5 - 637.3	MS	MVM	2006	5.5
Loosahatchie Bar	741.5 - 737.0	AR-TN	MVM	2008	11.25
Kangaroo Point	649.5 - 645.3	AR	MVM	2008	1.5
Below Ludlow	624.0 - 621.0	AR	MVM	2008	1.5
Island 70	610.0 - 605.7	MS	MVK	2011	3.5
Island 15	853.7 - 849.0	MO	MVM	2010/2012	2.5
Caruthersville-Linwood	846.0 - 839.0	MO	MVM	2012	5
Island 18 Towhead	838.5 - 834.0	TN	MVM	2012	3
Island 20	833.2 - 828.0	MO	MVM	2012	4
Kentucky Point	887.0 - 885.0	KY	MVM	2013	4
Ashport-Golddust	796.0 - 792.0	AR	MVM	2013	4
Wrights Point	822.0 - 816.0	AR	MVM	2013	3
Below Prentiss	578.0 - 577.0	MS	MVK	2013	4
Catfish Point	570	MS	MVK	2013	4
TOTAL					**56.75**

USACE Districts have constructed 774 dikes between river miles 212 and 953.5 (up to 2012) and 225 (29%) of these structures have been notched (USACE 2013). These notches increase bathymetric diversity, and therefore habitat, below the dikes (USACE 2013). Notching structures has also been directed to enhance secondary channels.

In addition to completing secondary channel projects, the LMRCC has worked in the river floodplain. An example is a project to restore a weir at Lake Perry Martin in Mississippi. The project permanently raised lake water levels, improved water quality, increased fish access and created better public fishing opportunities.

Combining the habitat restoration accomplishments of the LMRCC, USACE and other agencies, 76 of the original projects (30%) are in some stage of completion. Challenges associated with determining the status of these projects are the dynamic nature of the river, redistribution of sediment with high water events and the scour needed to connect secondary channels between individual dikes. For projects listed as complete, further evaluation may identify additional project needs.

COMPLETED PROJECT LOCATIONS

Map: Angela Erves and Bruce Reid

Project Focus	Work Completed	Work Begun	Work Not Initiated
Create, rehabilitate, and diversify secondary channels	23	30	41
Restore and diversify floodplain water bodies	3	1	37
Augment aquatic connectivity with the floodplain	1	2	25
Tributary enhancement	0	1	4
Create/rehabilitate wetlands	0	0	2
Diversify main channel habitat	1	14	32
Enhance terrestrial habitat	0	0	2
Improve recreational access	0	0	34
TOTAL	**28**	**48**	**177**

Note: Table includes projects completed by USACE, LMRCC and other agencies.

If you are reading this on a computer or mobile device, click or tap on the buttons to the right to view project maps for each state. If you are reading a printed version, go to: http://lmrcc.org/maps.

AR KY LA

MO MS TN

Amanda Oliver (above), a U.S. Army Corps of Engineers contractor, holds a Pallid Sturgeon during a survey of a restored side channel at Island 63. Dike-notching projects help protect nesting colonies of the Interior Least Tern (below) from predators.

Photos: U.S. Army Corps of Engineers and Bill Stripling

Ron Nassar (above, right), retired LMRCC coordinator, confers with contractors at the Island 70 dike-notching project. The LMRCC has completed three projects to restore floodplain lakes, including at the 25-acre Lake Perry Martin (left) near Rosedale, Mississippi.

Photos: Lower Mississippi River Conservation Committee

PROFILE IN RIVER RESTORATION

Upstream of the mouth of the White River, north of Rosedale, Mississippi, between River Mile 610 and 605, is a stretch of the Lower Mississippi River that is the focus of both aquatic and terrestrial habitat restoration.

Land fronting the river is known as Island 70. The Lower Mississippi River Conservation Committee (LMRCC) and its partners completed a dike-notching project there, restoring flow to 3.5 miles of side channel habitat.

In addition, 1,720 acres of cleared land (outlined in red) are being replanted as part of Lower Mississippi River Batture Reforestation Project managed by the Mississippi River Trust, LMRCC and Natural Resources Conservation Service.

BENEFITS

Improved Pallid Sturgeon habitat

Improved Interior Least Tern habitat

Improved Black Bear habitat

More recreational opportunities

Improved water quality protection

Climate change mitigation

Graphic: Bruce Reid

GOALS AND ACTIONS

Goals and actions have been developed to guide the process of habitat enhancement, rehabilitation and restoration of the Lower Mississippi River and its floodplain. Goals include:

HABITAT

Maintain or improve aquatic and terrestrial habitat quantity, quality and diversity, along with water quality, in the Lower Mississippi River ecosystem.

COORDINATION/COLLABORATION

Improve cooperation and collaboration among public agencies, navigation interests, NGOs, industries and municipalities to improve habitat or avoid, minimize or mitigate habitat losses.

PUBLIC USE AND ACCESS

Increase public use through enhanced access along the Lower Mississippi River.

HABITAT

1. LMRCC states will evaluate all proposed projects in their states and update as needed beginning in 2014.
2. Complete all proposed habitat restoration projects listed in Appendix A.
3. Quantify historical aquatic and terrestrial habitat conditions and subsequent losses.
4. Conduct pilot projects to better understand interaction between floodplain function and fish diversity and production.
5. Build large habitat complexes that include several different connected habitat types (e.g., islands, secondary channels, wetlands, batture reforestation and restoration of natural hydrology).
6. Restore natural hydrology within the batture through prevention or removal of unnatural barriers to flow.
7. Support levee setbacks, where appropriate, as an alternative to levee repair and to expand the existing floodplain.
8. Restore native terrestrial and wetland vegetation within the batture.
9. Work with willing landowners through easement or acquisition to accomplish priority projects.
10. Recommend measures to avoid, minimize and mitigate adverse impacts related to MR&T and CIP activities.
11. Work cooperatively to develop a mitigation bank for the LMR and its batture to compensate for impacts caused by flood control and navigation projects and commercial operations.
12. Design projects to benefit restoration of federally listed species as outlined in USFWS 1990, USFWS 2009, USFWS 2013a, and USFWS 2013c. Consider ways to benefit native species and deter exotic species during project design.

13. Utilize Hydraulic Sediment Response Models to design specific habitat restoration projects.
14. Support evaluations of river training structures (i.e., dikes, chevrons) and bank stabilization methods (i.e., ACM, riprap) as fish habitat and modify their design as needed and appropriate to the extent possible.
15. Identify beneficial uses for dredged material from the LMR during project design (e.g., wetland construction instead of main channel disposal).
16. Support pre- and post-project evaluations (e.g., hydrographic, biological and water quality) for select habitat restoration projects to determine benefits to the ecosystem.
17. Utilize the tool developed by ERDC to prioritize secondary channel restoration projects (Killgore et al. 2012).
18. Develop tools to prioritize the remainder of the projects in each of the other project focus categories (i.e., floodplain water bodies, wetlands, terrestrial).
19. Conduct at least one study to determine factors leading to gravel bar formation and stability.
20. Conduct at least one study each to determine sedimentation rates in secondary channels, floodplain water bodies and batture.
21. Design and construct projects that would help fulfill goals of the Clean Water Act.
22. Support legislation, programs and activities that reduce pollution and contaminants within the Mississippi River watershed.
23. Develop and fund a program to monitor water quality and fish populations in the LMR similar to the Upper Mississippi River Restoration Program's Long Term Resource Monitoring program.
24. Support efforts to develop and fund a spill contingency plan.

COORDINATION AND COLLABORATION

1. Finalize and implement the Lower Mississippi River Resource Assessment.
2. Invite partners to attend the annual LMRCC meetings, including the open session of the Executive Committee and its three technical sections (i.e., Habitat Restoration, Water Quality and Fisheries).
3. Work with the USGS and other agencies to develop and fund a long-term program to design, construct, maintain and evaluate habitat restoration projects (similar to the Upper Mississippi River Restoration Program).
4. Federal and state natural resource agencies should meet at least annually with each USACE District to discuss CIP and habitat restoration projects.
5. Encourage each USACE District to conduct annual on-board inspection trips along their reach of the LMR to view and discuss CIP and habitat restoration projects (e.g., similar to USACE St. Louis District).
6. Collaborate with the Mississippi Interstate Cooperative Resource Association, the Upper Mississippi River Conservation Committee, the Upper Mississippi River Basin Association and the Ohio River Fisheries Management Team in basin-wide goals and initiatives.
7. Maintain the LMRCC website.
8. Continue to utilize the Mississippi River Foundation to acquire needed funding to implement this plan.

PUBLIC USE AND ACCESS

1. Complete all proposed access enhancement projects.
2. Develop tools to prioritize access projects.
3. Enhance access and/or facilities on existing public lands to improve public use opportunities.
4. Identify additional public access needs.
5. Develop partnerships to implement access enhancement projects.
6. Maintain a GIS map of public land and access sites along the LMR and in the batture.

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ACKNOWLEGEMENTS

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Arkansas Game and Fish Commission
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Kentucky Department of Fish and Wildlife Resources
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Restoring America's Greatest River plan

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FISH AND WILDLIFE SERVICE

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August 8, 2017

Ms. Lisa Kiefel
Planning and Policy Division
USACE – Headquarters
441 G St. N.W.
Washington, D.C. 20314

Dear Ms. Kiefel:

The U.S. Fish and Wildlife Service supports the Feasibility Study of initiating key recommendations from the Lower Mississippi River Resource Assessment to: 1) Establish a water quality monitoring program in the Lower Mississippi River and 2) Conduct eight conservation reach habitat restoration and recreation enhancement studies on the Lower Mississippi River. This reasonable step will assure the Lower Mississippi River continues to provide for people and the natural inhabitants of the river system.
The Lower Mississippi River is a dynamic river, receiving flow from the Upper Mississippi, Ohio, Missouri and Arkansas rivers. Before discharging to the Gulf of Mexico through its distributary rivers, the Atchafalaya and mainstem Mississippi in Louisiana, the system is joined by the Red River; thus adding significant flow from parts of Louisiana, Texas, Oklahoma and New Mexico. This river has experienced numerous great floods while also carrying $50 B worth of agricultural products to export markets each year. The river is the economic and cultural driver for the people who live along its banks and serves as the life blood for the Gulf of Mexico.

The U.S. Fish and Wildlife Service (Service) developed a "Vision for a Healthy Gulf of Mexico Watershed" document in 2013, in response to restoration challenges following the Deepwater Horizon oil spill in 2010. The Lower Mississippi River Alluvial Valley was identified as one of the focal areas and specific next steps were outlined in an accompanying 2017 document "Next Steps for a Healthy Gulf of Mexico Watershed" (https://www.fws.gov/southeast/gulf-restoration/next-steps/). The document states: "Coordinate with the Lower Mississippi River Conservation Committee to implement recommendations from the Congressionally authorized Lower Mississippi River Resource Assessment to maintain navigation and abate flooding while enhancing river-related recreation and public access along with the river's natural habitats and the species they support. Recommendations include the creation of a Lower Mississippi River Science Technology and Information Center; the study of sediment budgets; the development of a water-quality monitoring program; the compilation of an inventory of ecological resources to support restoration; and the implementation of an invasive species program (particularly for the Asian carp)." As you can see, the proposed Feasibility Study directly ties to goals of the Service for restoration and improvement to the Gulf of Mexico.

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Building from past planning activities included in Restoring America's Greatest River plan and the Lower Mississippi River Resource Assessment, partners will prepare a Feasibility Study designed to implement priority restoration projects and establish sequencing for project implementation. At the same time, the fundamentals of establishing a water quality monitoring program will be addressed with an end-product that is ready for implementation. Water quality information is vital for managing the ecological health of the river but also provides valuable information for flood risk management, navigation and Gulf of Mexico health.

We would like to add our voice to the many partners that believe the Lower Mississippi River can be managed for flood risk management and navigation, in addition to ecosystem restoration and recreation. Please give this proposal your full consideration.

Sincerely,

Allan Brown
Assistant Regional Director, Fish and Aquatic Conservation
U.S. Fish and Wildlife Service

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LMRRA

Lower Mississippi River
Resource Assessment

Final Assessment
In Response to Section 402 of WRDA 2000

Public Review Draft
April 2015

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Executive Summary

Congress authorized the Lower Mississippi River Resource Assessment to examine river management information, habitat, and recreation; identify needs for each of these; and make recommendations for meeting those needs. The Assessment of Information Needed for River-Related Management found that information about sediment and water quality was lacking, data storage and availability need to be better managed, and a better understanding of tributaries would benefit management of the Mississippi River. The Assessment of Natural Resource Habitat Needs found there was a need to better understand water quality, restore the native vegetative mosaic, reconnect secondary channels, manage invasive species, improve the quality of floodplain habitats, inventory river islands, restore main channel habitats, support coastal wetland restoration, and develop plans to comprehensively restore entire river reaches. The Assessment of the Need for River-Related Recreation and Access identified the need for more and better boat ramps, bicycle trails, outfitter and guide services, lodging and dining options, riverside parks, interpretation, riverboat landings and marketing.

This Lower Mississippi River Final Assessment accumulated the needs identified in the previous assessments and found overlap among many of them. In fact most river related recreation is directly related to the natural resources and habitats on the river. This assessment recommends three programs to address the needs on the river. Each of these programs includes multiple studies and projects. The recommendations leverage existing programs and encourage both public and private investment in the river. All recommendations are compatible with navigation and flood risk management.

The recommended Data Information Science and Communications Program would create an interagency center to store and share information, support the ongoing sediment studies, establish a comprehensive water quality monitoring program, conduct studies on tributary watersheds, and complete ecological inventories of river islands and potential natural vegetation. This program would rely on the U.S. Army Corps of Engineers; U.S. Geological Survey; U.S. Fish and Wildlife Service; U.S. Environmental Protection Agency; the states of Illinois, Kentucky, Missouri, Tennessee, Arkansas, Mississippi, and Louisiana; and non-governmental organizations to implement. The program would benefit a variety of habitats and the species that rely on them, recreational users, local economies, navigation, flood risk management, and other river resources.

Data Science and Communications Program				
Recommendation		**Lead Organization**	**Cost**	**Value**
DISC 1	Science Technology Information Center	USGS – lead; USACE, EPA, NPS, USFWS, states and NGOs	$2 million/year	Promote interagency cooperation, encourage research, foster public interest, and support other recommendations.
DISC 2	Sediment Study	USACE	$4 million/year	Support management plans, better manage dredging and coastal restoration.
DISC 3	Water Quality Monitoring Program	USGS & EPA	$2 million/ year	Provide clean water for people, industry, and habitat.
DISC 4	Tributary Watershed Studies	USACE	11 @ $1-$5 million each	Develop plans to manage tributaries for habitat, water quality, sediment, water supply, navigation and recreation.
DISC 5	Ecological Inventory	USACE & USFWS	$1.7 million	Provide information to support restoration.

The recommended Habitat Restoration and Management Program would support restoration of river reaches, numerous individual aquatic habitat restoration projects, terrestrial habitat restoration, and invasive species management. This program would primarily rely on the U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, and the Lower Mississippi River Conservation Committee with their cooperating agencies, partners and states – Illinois, Kentucky, Missouri, Tennessee, Arkansas, Mississippi, and Louisiana. The program would benefit a variety of habitats and the species that rely on them, recreational users, local economies, and other river resources.

Habitat Restoration and Management Program				
Recommendation		**Lead Organization**	**Cost**	**Value**
HRMP 1	Conservation Reach Studies	USACE	8 @ $3 million each	Restore aquatic (side channel, oxbow, main channel, islands, and sandbars) and terrestrial (wetlands, bottomland hardwoods, and floodplain) habitats for native species and especially federally listed species.
HRMP 2	Aquatic Habitat Restoration Studies	USACE & USFWS	125 @ $200,000 to $ 15 million (maximum)	Restore individual sites for native species.
HRMP 3	Terrestrial Habitat Program	USDA & LMVJV	$18,000,000	Restore floodplain habitat.
HRMP 4	Invasive Species Program	MICRA & ANSTF	Part of larger effort	Promote and protect native species.

The recommended Recreation Program would support construction of boat ramps, bicycle trails, riverfront parks and riverboat landings; encourage coordinated marketing and interpretation; and entice lodging, dining and outfitter guide businesses. The program would rely on entrepreneurs to provide commercial services, and local community governments and organizations with assistance from the National Park Service to build public infrastructures. The program would benefit recreational users and local economies and would add visibility to all of the other resources of the river.

Recreation Program				
Recommendation		**Lead Organization**	**Cost**	**Value**
RP 1	Boat Ramps	LMRCC and others	$50,000 - $750,000 each	Increase safety and meet recreation demand.
RP 2	Bicycle Trails	NGOs	variable	Increase safety and meet recreation demand.
RP 3	Riverfront Parks	Local Communities	variable	Promote community cohesiveness and meet demand.
RP 4	Riverboat Landings	Local Communities	variable	Provide safe, accessible opportunities and support local economic development.
RP 5	Marketing	NPS, MRPC, NGOs	$2 million	Promote river use and encourage economic development.
RP 6	Lodging and Dining	Private Enterprise	variable	Meet demand and support economic development.
RP 7	Outfitters and Guides	Private Enterprise	variable	Increase safety, meet demand and support economic development.

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I. Introduction

This report is the final assessment for the Lower Mississippi River Resource Assessment. It follows three previous reports. The first examined the river to determine the information needed for river-related management. The natural resource habitat needs and the recreation and access needs were examined in the next two reports. This final assessment combines those results and recommends projects and programs to meet the identified needs in concert with the ongoing navigation and flood risk management programs on the Lower Mississippi River. These documents are available at: http://www.mvm.usace.army.mil/Missions/Projects/LMMRA.aspx

The Mississippi River is an American icon. The statistics about the river are impressive: drains all or parts of 31 states and 2 Canadian Provinces; is the third largest watershed in the world overlying one of the three most productive agricultural zones on the planet; provides drinking water for more than 18 million people; transports 62 percent of our Nation's agricultural output; delivers nearly 400 million tons of coal and petroleum products annually; and directly supports one million jobs. The numbers tell part of the river's story, but not all.

A thousand years before Christopher Columbus, a new culture arose and spread across the Mississippi Valley and the southeast. The culture was concentrated along the Mississippi River and is now called "Mississippian." Mississippian Indians included many tribes speaking different languages, but most belonged to either the Caddoan group (west of the river) or the Muskhogean (east). Many other tribes eventually adopted the new way of life. These tribes built hundreds of mounds up and down the river (Lewis & Kneberg 1958). Many of these mound complexes still exist and some are now state parks.

The first European to explore the Mississippi River was Hernando De Soto, who died on its banks in 1542. Jacques Marquette and Louis Jolliet followed in 1673; and in 1682, Robert LaSalle claimed the river for France. France ceded the river to Spain in 1763, but took it back in 1800. In 1803, President Thomas Jefferson purchased the Louisiana Territory from France despite agreeing that the Constitution did not contain provisions for acquiring territory. Jefferson believed the Mississippi River was an important trade route and he wanted to remove France's influence in the region (Robards 2003).

Control of the Mississippi River was a key military objective of the Union during the Civil War. General Ulysses Grant's Union forces pushed down from Cairo, IL and up from New Orleans, LA and met at Vicksburg, MS for a six week siege that ended July 4, 1863. Vicksburg National Cemetery is the largest interment of Civil War dead in the Nation. Port Hudson, LA was the last Confederate controlled fort on the river. The battle at Port Hudson was the longest siege in American history. It took 48 days, for 40,000 Union soldiers to defeat 7,500 Confederates. Shortly after the end of the war, Union soldiers who had been prisoners of war loaded onto the steamboat Sultana to go home. The steamship exploded near Memphis, TN and approximately 1,700 were killed. This tragedy is the largest maritime disaster in U.S. history.

John James Audubon was one of the first to document the incredible diversity of wildlife along the Mississippi River. He spent a great deal of time along the Mississippi River from St. Genevieve, MO to New Orleans. In 1821, he spent only four months at Oakley Plantation near

St. Francisville, LA but he made 32 bird paintings there. Audubon recognized that the Mississippi River is one of the most diverse river systems in the world and is rich in species and density of fish, birds, mammals, amphibians, reptiles, and invertebrates. Today, scientists know the Mississippi Flyway hosts the world's largest bird migration, and over 300 species of migrating birds use it.

Mark Twain is probably the best known ambassador of the Mississippi River. Twain grew up along the river and was a riverboat pilot. His *Life on the Mississippi* (1883) and *Huckleberry Finn* (1885) both chronicle life on the Mississippi prior to the Civil War. Although *Huckleberry Finn* was a work of fiction, it placed the Mississippi River into the consciousness of people around the world. Edna Ferber again brought the river to the public's attention with her 1926 novel *Show Boat* which became the Broadway show of the same name featuring Oscar Hammerstein's *Ol' Man River.*

Managing a river as large and powerful as the Mississippi has never been easy. Congress created the Mississippi River Commission in 1879 to advise lawmakers on the needs for flood risk management and navigation. The Federal Mississippi River and Tributaries Project levees, floodwalls, backwaters and floodways form the world's largest and most comprehensive flood risk management system. Navigation management began in the early 19th century and now Mississippi River commercial shipping is one of the Nation's valuable assets. On the upper Mississippi River, locks and dams were built to facilitate navigation. These features are not needed below the confluence with the Missouri River.

The Lower Mississippi River (LMR) begins at the confluence of the Mississippi and Ohio Rivers in southern Illinois and meanders southward 954 miles to Head-of-Passes, LA, where the channel subdivides into several distributaries to the Gulf of Mexico. The LMR has two distinct reaches. From the mouth of the Ohio River south to Baton Rouge, LA the river has well-defined point bars and forested floodplains adjacent to the river (Baker et al. 1991). The navigation channel is maintained at a minimum of 9 feet, but is authorized for 12 feet. Below Baton Rouge, the river flows through the Deltaic Plain to the Gulf. The channel is deeper to accommodate ocean-going traffic (45 feet), and there are few meander loops, sandbars, and little floodplain (Baker et al. 1991).

The LMR floodplain is a dynamic freshwater ecosystem that changes with the river's annual hydrologic regime. The nearly 3 million-acre floodplain is interspersed with abandoned channels, meander scars, and large expanses of forested wetlands. These areas provide a diverse array of aquatic habitat types and are connected to the river at high water. The LMR supports over 90 freshwater fish species and several federally listed threatened or endangered species. People still flock to the river to watch birds and other animals.

The Mississippi River is an economic powerhouse for the region. It generates over $150 billion dollars a year in revenues and employs over 580,000 people in the LMR area. Agriculture generates nearly $9 billion a year, navigation generates $4 billion, and river-dependent manufacturing brings $106 billion. Recreation and tourism within the LMR corridor generate nearly $17 billion in annual spending, support thousands of businesses and employ over 240,000 people (IEc & Dziegielewska-Parry 2014).

Interest in the Mississippi River as an economic engine, tourist destination and ecological resource is growing. Government agencies, industries, municipalities and non-governmental organizations are joining forces through America's Inner Coast Summit, America's Watershed Initiative, and the Mississippi River Cities and Towns Initiative (MRCTI), to promote the river and highlight its needs. In 2013, the MRCTI signed a Memorandum of Common Purpose with the U.S. Army Corps of Engineers (USACE) with a goal to "perpetuate an era of cooperation and collaboration between the Mayors on the main stem Mississippi River and the U.S. Army Corps of Engineers, to protect, sustain and enhance the natural attributes and economic vitality of the Main Stem Mississippi River."

The Mississippi River Commission developed a 200-year working vision for the river to insure that people can continue their lives on the Mississippi River. The vision balances the Nation's needs for security and flood damage reduction with environmental sustainability and recreation, infrastructure and energy, water supply and water quality, and navigation. They committed to five goals for the river to insure its value for future generations. This final assessment builds on these goals and the success of other efforts to manage the Mississippi River.

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Congressional Authority

The Lower Mississippi River Resource Assessment (LMRRA) is authorized by Section 402 of the Water Resources Development Act of 2000, Public Law 106-541. It reads:

(a) ASSESSMENTS- The Secretary, in cooperation with the Secretary of the Interior and the States of Arkansas, Illinois, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee, shall undertake for the Lower Mississippi River system--

> *(1) an assessment of information needed for river-related management;*
>
> *(2) an assessment of natural resource habitat needs; and*
>
> *(3) an assessment of the need for river-related recreation and access.*

(b) PERIOD- Each assessment referred to in subsection (a) shall be carried out for 2 years.

(c) REPORTS- Before the last day of the second year of an assessment under subsection (a), the Secretary, in cooperation with the Secretary of the Interior and the States of Arkansas, Illinois, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee, shall transmit to Congress a report on the results of the assessment to Congress. The report shall contain recommendations for--

> *(1) the collection, availability, and use of information needed for river-related management;*
>
> *(2) the planning, construction, and evaluation of potential restoration, protection, and enhancement measures to meet identified habitat needs; and*
>
> *(3) potential projects to meet identified river access and recreation needs.*

(d) LOWER MISSISSIPPI RIVER SYSTEM DEFINED- In this section, the term `Lower Mississippi River system' means those river reaches and adjacent floodplains within the Lower Mississippi River alluvial valley having commercial navigation channels on the Mississippi mainstem and tributaries south of Cairo, Illinois, and the Atchafalaya Basin floodway system.

(e) AUTHORIZATION OF APPROPRIATIONS- There is authorized to be appropriated $1,750,000 to carry out this section.

Plan Purpose

The purpose of this final assessment is to develop a strategic approach to managing habitat restoration, recreational opportunities and the information needed to make river management decisions. Historically, the navigation and flood risk management systems have received most of the attention on the LMR. Habitat and recreation have not been managed as systems on the LMR, but planning for these uses is starting to receive focus from many entities.

Goal

The goal of this Final Assessment is to summarize the needs for information, habitat, and recreation identified in the three previous assessments and develop a strategy to meet those needs. The strategy should be holistic and sustainable; reconnect Americans with the great outdoors and the country's rich legacy of rivers; develop a comprehensive plan for habitat restoration, protection and enhancement; and promote collaboration between the public and private sectors to leverage investments.

Problems

Extensive structural changes on the river's main stem have disrupted the once dynamic ecosystem. The Mississippi River Levee system has disconnected much of the floodplain from the river. There is less available habitat for threatened and endangered species including interior least tern, pallid sturgeon, and fat pocketbook mussels. The region is underutilized for recreation and underappreciated for its cultural legacy. Additionally, information has not been gathered, stored or analyzed to enable strategic decision-making. The specific problems in the LMR are:

- Data is scattered among diverse government agencies, environmental organizations, industries and institutions.
- There is no integrated knowledge management database or decision support system.
- System-wide assimilation and assessment of data is difficult.
- Although water quality is generally good, localized problems occur and affect some listed species and high nutrient loads contribute to Gulf of Mexico hypoxia.
- Vegetative diversity has been reduced.
- Many side channels, backwaters, and oxbows are disconnected from the main channel.
- Native flora and fauna do not compete well against some invasive species.
- Some gravel bars and sandbars have been lost or degraded.
- The size of the floodplain and the associated habitat has been reduced.
- Mississippi River islands are a unique and limited habitat type, but their ecological importance is not fully understood.
- Coastal wetlands are declining.
- Habitat diversity in the main channel has decreased.
- There is a shortage of motorboat access in some areas.
- Existing access points are not conducive to canoeing and kayaking.
- There are not enough bicycling trails and very few in a natural or rural setting.
- Riverfront access is only available around urban areas.

- There are few interpretative centers/signs and they are scattered.
- There is no “one-stop” organization to provide information for all of the recreational facilities available in the region and market it as a recreational destination.

Opportunities

There are opportunities to restore habitat and ecosystem function in the LMR to benefit a variety of species, and to develop a recreation and access plan to improve facilities and promote recreation along this iconic river. There is also an increasing opportunity for public and private collaboration to restore habitat, increase recreation access and promote information sharing. The opportunities vary in different reaches of the river, and not all occur throughout the entire LMR. This final assessment generally recommends further, more in depth studies related to these opportunities. Some of the specific opportunities are:

- Identify the information river managers need to make strategic decisions.
- Compile river-related information and make it accessible.
- Manage water quality in the river better.
- Restore vegetative diversity in the active floodplain.
- Re-connect side channels, backwaters, and floodplain lakes where feasible.
- Promote native species restoration in areas where invasive species have become common.
- Restore and protect sandbars and gravel bars.
- Improve the quality of floodplain habitats.
- Inventory islands to understand their ecological value and develop management plans.
- Restore some habitat diversity in the main channel.
- Provide better motorboat access.
- Provide more canoeing and kayaking access.
- Provide more designated bicycling trails.
- Improve heritage tourism.
- Improve publicly accessible riverfront areas.
- Develop more and better interpretative services and facilities.
- Create informational and marketing materials the public can use to learn about and plan recreational activities.

Objectives

These objectives were developed to guide the analyses of needs and lay the foundation for the final assessment.

- Evaluate the information needs of Mississippi River resource managers.
- Identify information gaps that could be filled to better guide LMR projects for the foreseeable future.
- Compile a list of available information that may be of interest to river managers and users now and into the foreseeable future.
- Develop a strategy to make the river data accessible and maintain it for future users.

- Identify habitat needs on the LMR.
- Develop recommendations for habitat restoration studies and programs for the LMR.
- Develop recommendations to foster collaborative habitat management.
- Identify unmet recreation demands in the region.
- Develop recommendations for recreation facilities to meet demands in the region.
- Develop a conceptual strategy to market the region for recreational use.
- Identify mechanisms that will allow public – private partnerships to develop and promote recreational use on the region.

Study Area

The study area extends from River Mile 953 of the main stem Mississippi River channel south of Cairo, Illinois, downstream to River Mile 0 (Head of Passes) in Louisiana (see map on page 8). The area encompasses the main river channel and the area between the Mississippi River and Tributaries Project levees or natural high ground (batture), including the mouths of all tributaries between the levees. The study boundary extends up the following rivers and canals that have existing commercial navigation (i.e. commercial barge traffic) to the point of direct influence between each channel and the main stem Mississippi River: the White River upstream to Clarendon, AR; the Arkansas Post Canal upstream to Norrell Lock and Dam, AR; the Yazoo River upstream to Greenwood, MS; the Red River upstream to Lock and Dam No. 2, LA; the Ouachita/Black River upstream to Columbia Lock and Dam, LA; and the Old River from the Old River Lock to its confluence with the Red and Atchafalaya Rivers in Louisiana. For the recreation needs assessment, the study area was expanded to include recreational features and needs related to the Mississippi River that lie beyond the bounds of the active floodplain. The study area includes areas which can or do provide facilities necessary for recreational use along the river. The exact geographic extent is not definitive, but it covers the entirety of the counties touching the active floodplain and the Great River Road National Scenic Byway.

The Atchafalaya Basin Floodway System in Louisiana is also included within the authorized project area. Future public access areas and types of recreation features were already identified in the Atchafalaya Basin Floodway System Master Plan. The plan includes recommendations for public use lands, campgrounds, boat ramps, a visitor center and interpretive trails as well as recommendations for flowage easements, canal closures and water management units. There are ongoing state and Federal programs to manage and improve habitat within the Atchafalaya Basin. USACE has acquired over 350,000 acres in easements and 70,000 acres in fee land within the Atchafalaya Basin to preserve habitat and maintain public access. The State of Louisiana has developed an Atchafalaya Basin Program to oversee the state's Atchafalaya Basin Master Plan that brings together USACE, state agencies, and Basin parishes to protect and enhance the natural resources of the Atchafalaya Basin. Sedimentation in backwater areas is the biggest threat to the conservation of aquatic habitat in the Atchafalaya Basin. As such, restoration activities have mainly focused on sediment management to improve habitat and alleviate poor water quality in backwater areas. These ongoing projects address the needs in the Atchafalaya Basin and no further analysis was done for this study.

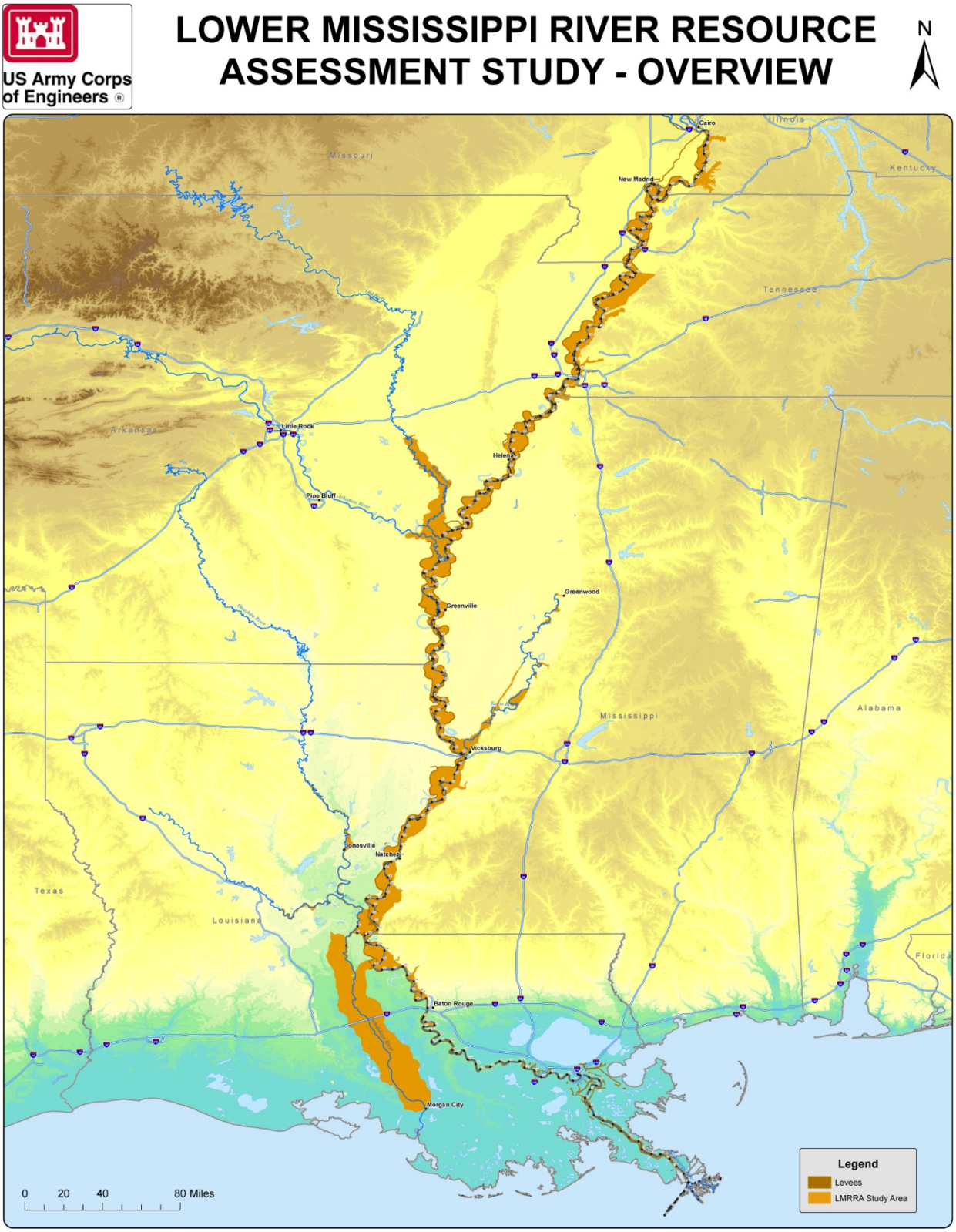

Figure 1. Study Area

Partnership

The Nature Conservancy (TNC) Great Rivers Partnership is the study cost-sharing sponsor. TNC signed agreements with a group of non-governmental organization partners who are providing work-in-kind study services. The study team includes staff from TNC North America Freshwater Program and TNC State Chapters in Tennessee, Louisiana and Mississippi, Lower Mississippi River Conservation Committee (LMRCC); National Audubon Society; and Mississippi River Corridor-TN. All of these groups focus on sustainable river management and conservation and collectively they represent thousands of river users.

The LMRCC is a coalition of 12 state natural resources conservation and environmental quality agencies from Arkansas, Kentucky, Louisiana, Mississippi, Missouri and Tennessee. It provides the only regional forum dedicated to conserving the natural resources of the Lower Mississippi River floodplain. LMRCC focuses on habitat restoration, landscape level conservation planning, and natural resource-based economic development. The U.S. Fish and Wildlife Service (USFWS) leads the effort and provides a full time coordinator. The U.S. Geological Survey (USGS), USACE, U.S. Environmental Protection Agency (EPA), and U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) are cooperating agencies.

II. SUMMARY OF NEEDS ASSESSMENTS

The three LMRRA needs assessments have already been completed. Each assessment identified needs, but did not include any recommendations to meet those needs. The executive summary of each assessment is presented here. The complete documents with references are available for review at: http://www.mvm.usace.army.mil/Missions/Projects/LMMRA.aspx

Assessment of Information Needed for River-Related Management

This assessment began in January 2012. Public scoping meetings were held in Memphis, TN in July 2012, Vicksburg, MS in August 2012 and Baton Rouge, LA in September 2012. The report was released for public comment in June 2013. USACE headquarters concurred with the final assessment in October 2013.

This report assessed information needed for river-related management on the Lower Mississippi River from its confluence with the Ohio River at Cairo, IL to the Head of Passes, LA.

The study team identified issues raised during scoping, examined river management activities, and collated information sources. These steps revealed four areas of information needs for river management. The information needs are related to sediment, water quality, data storage and availability, and tributary management.

Many of the world's great rivers have sediment monitoring and management plans, but there is not one for the Mississippi River. Sediment is both a management problem and a valuable asset in the river. Sediment monitoring has not been done consistently on the Lower River. A systematic monitoring and measuring protocol and the development of predictive sediment models would give river managers the tools to develop a sediment management plan. This would benefit flood risk management, navigation, fish and wildlife, coastal habitat, water supplies and Gulf of Mexico hypoxia.

Clean water is vital to the nation's economy. Water quality in the Mississippi River is generally good and continues to improve, but monitoring is not well coordinated among the seven states along the Lower River. The sources and fates of nutrients, pathogens and contaminants in the river have not been clearly delineated. A coordinated water monitoring and analysis program for the river and tributaries would give managers the tools to make informed decisions and develop comprehensive management plans to continue improving water quality. This would benefit fish and wildlife, recreation, water supplies, coastal habitat and Gulf of Mexico hypoxia.

Data availability is important for all river management. Much of the data for the Lower River is held in agency files and databases. A substantial amount of historic data only exists as paper files and maps that can only be accessed in person. River managers either make decisions without some information or invest resources to generate information that may already exist. A centralized data management system that stores some information and provides linkages to the rest would give river managers and the public access to the best information available. This is vital to improved management of water quality and sediment.

Tributaries are some of the most significant sources of nutrients and sediment to the main-stem of the Lower Mississippi River. There has been very little geomorphic analysis of tributary

streams to better understand how they interact with the river. Comprehensive watershed management will be a necessary part of enhanced water quality and sediment monitoring programs and tributary river restoration. It is important for water quality, sediment, hypoxia, habitat, and fish and wildlife management.

Assessment of Natural Resource Habitat Needs

This assessment began in July 2013. Public scoping meetings for both the natural resource habitat and recreation assessments were held in Dyersburg, TN in July 2013, and Helena, AR and St. Francisville, LA in August 2013. The report was released for public comment in November 2014. USACE headquarters concurrence on the final document is expected in spring 2015.

This report assessed the natural resource habitat needs for the Lower Mississippi River from its confluence with the Ohio River at Cairo, IL to the Head of Passes, LA.

The Mississippi River and the land between the levees are a dynamic ecosystem that changes markedly in response to the river's annual hydrologic regime. The nearly 3 million-acre floodplain is interspersed with abandoned channels, meander scars, and large expanses of forested wetlands. These areas provide a diverse array of aquatic and terrestrial habitat types.

The Mississippi Flyway hosts the world's largest bird migration, connecting life from the Arctic to South America. Over 300 species of migrating birds and approximately 70% of the Nation's migratory waterfowl use the flyway. The river also supports over 90 freshwater fish species.

This assessment found nine areas of habitat needs on the Lower River and identified several plans that have already been developed to answer some of these needs.

The Mississippi River receives water from 31 states. The water contains many contaminants and nutrients. Water quality is not a major limiting factor in the river ecosystem, but there is very little information about localized water quality effects, especially in backwaters, and side channels. There is a need to better understand water quality in secondary and tertiary habitats that are important for some life stages of fish and mussels.

The need to restore bottomland hardwood in the Lower Mississippi River Valley has long been recognized and is a priority for many entities, but other vegetation types have also declined. There is a need for research to examine current hydrology, soils and historic vegetation within the batture and develop tools to direct restoration species selection. This information would increase the success of restoration efforts. There is also a need to control or eliminate invasive plant species where they threaten restoration or preservation efforts.

There is a need to reconnect backwaters, side channels and floodplain lakes with the main channel at normal water levels. The Restoring America's Greatest River Initiative identifies specific opportunities for restoring some of this habitat. The federally listed interior least tern, pallid sturgeon, fat pocketbook mussel, and many other species in the Lower Mississippi River would benefit.

Most of the species native to the Lower Mississippi River are still present and their populations are viable, but the species abundance of many has declined. Habitat changes along the main stem and up the tributaries have caused most of the changes for mammals and birds, but the main factor driving aquatic population changes has been the introduction of exotic aquatic species such as carp and zebra mussel. There is a need for comprehensive studies of tributaries to understand their habitat value to the overall Lower Mississippi River system and there is also a need to control invasive species especially where they threaten native species.

Dynamic river forces form, enlarge, erode, move, and destroy sandbars and gravel bars. On established sandbars, high water removes existing vegetation and deposits new sand. Sandbars are the primary habitat component used for interior least tern nesting. Gravel bar habitats are important as spawning substrate for pallid sturgeon and other fish species. There is a need to protect and restore gravel and sand bars. The Conservation Plan for the Interior Least Tern, Pallid Sturgeon, and Fat Pocketbook Mussel addresses management and restoration of these features and the Restoring America's Greatest River initiative also identifies the need to conserve and restore them.

The Mississippi River active floodplain is now 80% smaller than it was historically (Baker et al 1991). The decrease in area inundated impacts water quality, habitat and species. The floodplains of tributary rivers may have become more important since the Mississippi River floodplain has been reduced. Cities, farms, highways, factories and other developments have moved into the historic floodplain. There is a need to assess tributary rivers to determine how their floodplains can be better managed to compensate for some of the loss of floodplain area. On the main stem Mississippi River, there is a need to restore the quality of habitat within the batture.

Many Mississippi River islands have been lost or altered. Islands offer important edge habitat. Since the islands are isolated from the bank, they afford many species safe places for sensitive life cycle events such as nesting. There is a need for an ecological inventory of islands in the LMR to determine their value for habitat and potential for restoration.

Preserving and rebuilding coastal wetlands is a recognized need and projects and programs are in place to address the problems. *Louisiana's Comprehensive Master Plan for a Sustainable Coast* sets forth a long term plan to address coastal needs in that state.

Habitat in the Mississippi River main channel was once very diverse, and provided a variety of substrates and flow conditions. Habitat complexity in the main stem has been reduced. Fish species, such as pallid sturgeon, primarily use the main channel of the river and rely on the diverse habitats for their various life stages. There is a need to restore some of the diversity in the main channel of the Mississippi River where it is compatible with navigation.

The Mississippi River ecosystem is a dynamic system with interactions between the terrestrial and aquatic systems, main channel and side channel areas, mudflats, backwaters, tributaries and islands. There is a need to examine the Mississippi River and batture at an ecologically meaningful scale. There are some priority reaches of the river where there are opportunities to

enhance a broad spectrum of features, i.e. restorable side channels, backwaters, and oxbows, a wide floodplain, large islands, populations of threatened and endangered species and sand bars. These areas should be examined holistically to develop plans for restoring all of the vital ecological elements.

Assessment of River Related Recreation and Access Needs

This assessment began in March 2013. Public scoping meetings for both the natural resource habitat and recreation assessments were held in Dyersburg, TN in July 2013 and Helena, AR and St. Francisville, LA in August 2013. The report was released for public comment in July 2014. HQUSACE concurred with the final assessment in December 2014.

This report assessed the need for river-related recreation and access on the Lower Mississippi River from its confluence with the Ohio River at Cairo, IL to the Head of Passes, LA.

More than 140 million Americans participate in outdoor recreational activities. The outdoor recreation industry supports 6.1 million American jobs and generates $646 billion in spending each year. In the Lower Mississippi River Region, outdoor recreation and tourism combine to generate nearly $17 billion annually and over 240,000 jobs (Yellowwood 2013).

The study team identified eight areas of need on the Lower River: boat ramps, bicycle trails, outfitter and guide services, lodging and dining, parks and vistas, interpretation, riverboat landings and marketing. Addressing some of the recreation and access needs on the Lower River would add to residents' quality of life, and bring increased revenues and jobs to the region and the nation.

Fishing and paddling generate nearly 900,000 American jobs and $9 billion in Federal and state tax revenues annually. The biggest obstacle to expanding fishing and paddling use of the Lower Mississippi River is the lack of well located boat ramps. There are only 129 boat ramps along the 954 miles of the Lower Mississippi River. Many ramps were designed for large boats and are not safe for small craft.

More than 60 million Americans ride bicycles. Bicycling generates 1.1 million American jobs, and $81 billion in annual spending. More bicycle lanes are being built in urban areas and the public would like to link these urban systems to bicycle trails in more rural settings with less traffic.

Outfitter and guide services in the Lower Mississippi River Region can provide safe, convenient options for people who want to hunt, fish, paddle and bicycle. The services are very limited but the increasing popularity of paddling and bicycling along with hunting and fishing create a good opportunity for small businesses all along the River.

Lodging and dining are readily available in urban areas, but are lacking in rural areas. Long distance bicyclists and paddlers, hunters and fishermen, and families visiting cultural and historic sites could all use more lodging and dining options in rural areas.

Many of the small towns on the Lower Mississippi River have no public space along the riverfront for picnics or even good views of the River. The topography of the Lower River limits

the number of natural vistas providing broad views of the River and some of the places that could provide a view are not accessible. Riverside parks are excellent areas for interpretive centers that tell the story of the River and its habitat, value for navigation, and flood risk management system.

Riverboats are making a comeback on the Mississippi River. The boats dock at small towns and big cities along the length of the River and offer excursions to see cultural and historic sites, participate in local activities, and take guided trips into natural areas. Many small towns do not have adequate docking facilities and miss the revenue from riverboat visits when the River is too high or too low.

The Lower Mississippi River passes seven states and many cities. There are many opportunities for outdoor recreation and tourism, but there is no single entity marketing the Mississippi River for tourism. Many visitors to the region come for a single purpose and are unaware of other opportunities.

III. CUMULATIVE CONCLUSIONS

The three needs assessments were narrowly focused, and each one identified needs specific to that focus. Most of the identified needs touch on other needs, and there are interactions among them. This section describes each need, which assessments identified it, what other needs it interacts with and the benefits of addressing the need. The next section of the report includes recommendations to meet the needs. Plans that are already in place to address the needs are also described.

Water Quality

All three assessments identified a need for better water quality monitoring and management. This need is related to sediment, data management, tributary management, vegetative mosaic, side channel, faunal community, floodplain, coastal wetland, main channel habitat, interpretation, marketing, and safety issues.

Water quality regulations were set forth in the Clean Water Act of 1972. The EPA delegates most of the responsibility for enforcing the Act to the individual states. Each state has broken the Mississippi River into segments and designated uses for each segment. Water quality standards are set to protect the existing and designated uses. The states conduct water quality monitoring and periodically report the compliance status of the water quality standards. Not all of the states conduct monitoring on the LMR. The Clean Water Act spurred more water quality monitoring for the LMR, but there is still no comprehensive monitoring program. A centralized data repository would be necessary to support a comprehensive program.

Nutrients and contaminants enter the Mississippi River from both point and non-point sources including air deposition and contaminants are sometimes bound with sediment. There are storm sewer systems, industrial discharges and agricultural runoff. Contaminated water affects fish and amphibians, requires more treatment for drinking water, and carries human pathogens. Endangered pallid sturgeon are long-lived fish, and contaminants can bioaccumulate in them even if the contaminant levels in the water are moderate to low. Recent studies point to this as one cause for sturgeon decline (Divers et al. 2009, USFWS 2009, Blevins 2011, Schrey et al. 2011).

Excess nutrients lower dissolved oxygen and cause eutrophication in side channels and oxbows. Nutrients attenuate as the river spreads out over the floodplain, but the floodplain area is now over 80 % smaller than it was historically (Baker et al. 1991). Research indicates most of the excess nutrients are coming from the upper and middle river; but reforestation in the batture and restoration of side channels and backwaters could attenuate some nutrients, reduce hypoxia, and improve overall water quality. Tributary watersheds are nutrient and contaminant sources and must be addressed to improve water quality in the river.

Water quality is an important aquatic habitat variable in the LMR (Baker et al. 1991). Low oxygen levels impact fish species richness and abundance in river backwater areas, river channels, and lakes (Killgore & Hoover 2001). There are localized problems such as chemical

spills or instances of low dissolved oxygen in backwaters or harbors that kill fish, but there is very little documentation of these events.

Coastal wetlands and the hypoxic zone in the Gulf of Mexico are outside the study area, but they are dependent on Mississippi River water. The LMR collects and transports water, sediment and nutrients from the entire Mississippi River watershed to the Gulf of Mexico. Some of the water and sediment is diverted to replenish coastal wetlands, but levees direct most of it out to deeper water. The hypoxic zone forms in the northern gulf every summer. It has been as large as 5.5 million acres. Hypoxic conditions stress and kill bottom-dwelling organisms and drive fish from the area (EPA 2007, MRGOWNTF 2008, Bianchi et al. 2010, Kroger et al. 2012).

Although water quality in the Mississippi River is relatively good and steadily improving, for example total nitrogen has decreased from its high in 1990 (Turner et al. 2007), the general public perception is that water quality in the river remains poor. The combination of nutrients and contaminants can lead to changes in water color and odor that can be off-putting to recreational users. Conflicting advisories on fish consumption add to the public's misperception. There are public concerns about the safety of water contact while fishing or paddling on the river. Marketing and interpretative tools are needed to address public concerns and promote the Mississippi River for recreation.

Improving water quality monitoring and management would benefit fish and wildlife, fishermen, paddlers, municipal water supplies, industries and others who rely on the Mississippi River for clean water. Clean water is vital to the economy of the nation and the quality of life in the Lower Mississippi River Valley.

Delivering water and treating wastewater is an energy-intensive effort. The water is treated, pumped to homes and businesses, and pumped to wastewater facilities to be treated again. The water supply and sewerage industry generates an estimated $385 million in annual revenue (IEc & Dziegielewska-Parry 2014).

The Mississippi River/Gulf of Mexico Watershed Nutrient Task Force was established in 1997 to understand the causes and effects of eutrophication in the Gulf of Mexico; coordinate activities to reduce the size, severity, and duration of the hypoxia; and ameliorate its effects. The Task Force includes five Federal agencies – USACE, USDA, Department of the Interior, EPA, and National Oceanic and Atmospheric Administration – twelve states, and the National Tribal Water Council. The primary priority of the Federal agencies is to provide broad support to the development and implementation of the state prepared nutrient reduction strategies.

The Task Force has identified five priorities: 1) monitoring to demonstrate water quality progress; 2) in-basin and Gulf modeling to demonstrate water quality progress; 3) regulatory program activities; 4) outreach, education, and initiatives; and 5) innovation to expand partnerships and technical assistance. A variety of programs and tools are being used and improved to accomplish these priorities.

Sediment

The information and habitat assessments identified a need for better sediment monitoring and management. This need is related to water quality, data management, tributary management, sandbar, floodplain, and coastal wetland issues. A centralized data repository would be necessary to support a comprehensive program. Tributary watersheds are nutrient and contaminant sources and must be addressed to manage sediment in the river.

Prior to the 1930's, most of the sediment in the Mississippi River came from caving banks and was stored primarily within the channel as sandbars and regular sediment input maintained coastal wetlands. Since that time, revetments have reduced bank caving limiting sediment input. Dikes now trap much of the bedload and levees limit the overbank areas (Kesel 2003). Sandbars are now rarer, and there is less sediment available to replenish coastal wetlands.

The Mississippi River is a naturally turbid system and the native species are adapted to it. Lower levels of suspended sediments may favor non-native species. Deposition of finer sediments can cover spawning substrate making it unusable for some fish species, and it is less stable for mussels and other invertebrates (Krinitzsky 1949, Harmar 2004, Harmer et al. 2005, Nittrouer et al. 2010, Allison et al. 2012). Sandbars are the primary habitat component endangered interior least tern use for nesting (Sidle et al. 1992, Thompson et al. 1997, Friedman et al. 1998, Johnson 2000, Leslie et al. 2000, Wiley & Lott 2012).

Sediment management is a vital and costly endeavor on the LMR. USACE spends up to $170 million annually dredging sediment in the Lower Mississippi River to maintain the navigation channel. Louisiana's Comprehensive Master Plan for a Sustainable Coast calls for more than $25 billion to be spent on a variety of projects, most involving water and sediment management. Understanding sediment dynamics is important for river management. Sediment management plans are in place for many of the world's great rivers: the Rhine (Europe), the Blue Nile (Africa), the Yangtze (Asia), the Columbia (North America), and the Darling (Australia). These plans are benefitting coastal areas, navigation, hydropower, and land conservation around the world.

Data Storage and Availability

The information assessment identified the need for a data management program to capture, store and make available all of the existing and future data for the LMR. The habitat assessment noted the need for more research and public education on several topics, and a central information system would respond to that need. The recreation assessment found there was a need for public education about the river, better interpretative facilities, a comprehensive marketing program, and safety information. When taken together, these conclusions point to the need for a public facility to house scientific, social, commercial, historical and other information about the river. The center needs to have the ability to support outreach programs and promote the LMR for research, tourism, outdoor recreation, and a variety of other uses.

Tributary Management

All three assessments identified a need to understand and manage the tributaries that provide, water, sediment, fish, habitat, and recreational access to the river. There are over forty tributary watersheds to the LMR that are large enough to have significant impacts on the river. Tributary management is related to sediment, water quality, faunal community, floodplain, boat ramp, and bicycle trail issues. The sheer size of the Mississippi River presents a management challenge to state and Federal agencies. Tributaries cross fewer state boundaries than the main stem river and are a manageable scale for comprehensive assessments.

A majority of LMR tributaries have been altered to facilitate drainage (Benz & Collins 1997). Channelization has reduced or eliminated natural stream functions in many tributary systems. These functions include but are not limited to providing habitat for freshwater mussels, crayfish, fish, amphibians, reptiles, mammals, and birds. Studies have documented population declines to all of these resources as a result of habitat loss (Benz & Collins 1997). Channelization in tributary rivers has also altered geomorphology and changed sediment dynamics.

During storm events, rain is quickly drained from the floodplain and the timing and duration of flood pulses in the tributary rivers have changed (Baker et al. 2004). Nutrients have less opportunity to attenuate on the floodplain. Tributary rivers are important habitats for fish and mussels, and the watersheds contain forested patches. Conversion of forests to crop lands has disconnected forest patches and altered biotic community structure and function, but there are opportunities to increase habitat connectivity between the river and some of the larger tributaries.

The Mississippi River also exerts an influence on tributaries, and many experience some backwater flooding. Changes in the Mississippi River can cause aggradation or degradation in the tributary channels (Biedenharn et al. 2000).

Tributary rivers also provide opportunities to meet recreation demands. They offer calm areas to launch canoes, kayaks and small fishing boats. Bicycle trails within the tributary watersheds would be a valuable addition to the overall network of trails and could provide access points to the Big River Parkway bicycle trail.

Vegetative Mosaic

The habitat assessment identified the need to conduct a potential natural vegetation study and use the results to maintain and reestablish the vegetative mosaic within the batture. The information and habitat assessment both noted the value of native vegetation in attenuating nutrients. The recreation assessment acknowledged that the diverse habitats in the batture supported exceptional, year-round wildlife watching. The vegetative mosaic in the LMR is related to side channel, faunal community, floodplain, and outfitter and guide issues.

Historically, a variety of vegetative communities was interspersed throughout the floodplain. The soil and hydrologic regime influenced what species occurred in any given area. Bottomland hardwoods (oak, hickory, pecan, tupelo, bald cypress, et al.) were the most common species in the floodplain, but softwoods (cottonwood, elm, ash, hackberry, et al.) were also present. Forest

types included cypress-tupelo, cottonwood-willow-sycamore, white oak-red-oak-hickory, hackberry-elm-ash, and many others (Klimas 1988, Stanturf et al. 2000, Gardiner et al. 2005). Drastic vegetation changes began after the levee system was complete and soybean prices rose in the 1950's. Between the 1950's and 1970's, nearly 300,000 acres were cleared and converted to agriculture every year (King et al. 2006).

Threatened Louisiana black bears depend on large, complex forest structure for forage, nesting or bedding sites, and successful reproduction (USFWS 1995). The flood prone forest species that now dominate the batture are less complex and not as suitable for black bear. Reptiles, amphibians, and many mammals, including the Indiana and gray bats, also depend on bottomland hardwood forests for cover, food, and successful reproduction. Forest interior song birds are dependent upon large expanses of bottomland hardwood forests. Fragmentation, human disturbances, and high edge to area ratios are causing songbird populations to decline (Twedt et al. 2002, Twedt et al. 2008). Game species that depend on diversity of habitat include white-tailed deer, wild turkey, squirrel, rabbit, and many species of waterfowl (LMVJV 2012). Many species, like American woodcock, rely on the early successional stages of bottomland hardwoods (Kelley et al. 2008).

River cane or giant cane was once common in the valley, but approximately 98% of this ecosystem has been lost throughout its range to agriculture, altered fire regimes, altered flood regimes, and grazing (Brantley & Platt 2001). Canebrakes are prime habitat for several species including the Louisiana black bear, Swainson's warblers, and several species of butterflies are also known as cane obligates (Platt & Brantley 1997, Brantley & Platt 2001, Hendershott 2002, LMVJV 2007).

The floodplain of the LMR has emergent, floating, and submersed aquatic vegetation, but their occurrence and distribution is dependent on the flow regime and elevation relative to the main stem river. Areas near the main channel are usually devoid of vegetation due to the scouring effect of moving water, except for duckweed that can become abundant after early isolation from the river. Submersed aquatic vegetation occurs in waterbodies furthest removed from the main stem river, such as borrow pits (personal communication, Dr. Jack Killgore, ERDC).

Invasive plant species pose a serious risk to native species. Kudzu was first introduced to the U.S. in 1876, and the erosion control programs of the 1930's to 1950's caused its spread. It now covers 2 million acres of forest land in the southern United States (Forseth & Innis 2004). Kudzu is an aggressive, fast growing vine and is very heavy. It covers other plants blocking out sunlight, girdling stems, breaking branches and even uprooting trees (Forseth & Innis 2004, NPS 2010). Privet was introduced to the U.S. in the mid-19th century as an ornamental shrub. It has invaded many areas in the LMR that are now drier than they were historically. It crowds out native understory vegetation (Merriam & Feil 2002). Neither of these plants provides suitable habitat for native species.

The diverse habitats in the valley support valuable recreational activities. In 2011, nearly 72 million people 16 years old or older spent about $55 billion on wildlife watching. There are 46.7 million bird watchers. Waterfowl, raptors, and songbirds attract the most interest. In 2011, hunting trips accounted for 22% of all outdoor recreation trips in the region. There are nearly 14

million hunters in the United States and they spend over $30 billion every year (USDI 2011) and generate 323,000 American jobs (Yellow Wood 2013). There are 8.3 million hunting trips taken in the area each year (IEc & Dziegielewska-Parry 2014).

The Lower Mississippi Valley Joint Venture (LMVJV) is a self-directed, non-regulatory private, state, and federal conservation partnership. LMVJV's goal is sustaining bird populations and their habitats within the Lower Mississippi Valley and West Gulf Coastal Plain regions. They implement and communicate the goals and objectives of relevant national and international bird conservation plans (LMVJV 2002). The Lower Mississippi Valley Joint Venture Plan was formulated to address problems that traditionally confronted wetland conservation in the region; namely, clearing of forests for agriculture and extensive alterations of wetland hydrology resulting from basin-wide flood control and drainage.

The NRCS provides technical and financial assistance to landowners for water quality and wetlands improvement projects. NRCS has established the Mississippi River Basin Healthy Watersheds Initiative to improve the health of the Mississippi River Basin. Through this Initiative, NRCS and its partners help producers in selected watersheds in the Mississippi River Basin voluntarily implement conservation practices that avoid, control, and trap nutrient runoff; improve wildlife habitat; and maintain agricultural productivity. They plan to restore over 11,000 acres of wetland habitat and prevent sediment and nutrients from entering waterways, decrease flooding, and improve bird and fish habitat. Approximately two thirds of the work is within the batture. The Wetlands Reserve Enhancement Program, part of the agency's Wetlands Reserve Program, provides the funding. Between 2010 and 2013, the NRCS formalized agreements with 47 landowners in the basin, investing $17.8 million in long-term conservation easements and wetland restoration projects.

Side Channels, Backwaters and Oxbows

The habitat assessment identified the need to restore side channels, backwaters and oxbows. The recreation assessment noted that these areas are good places for boat ramps. Side channel, backwater, and oxbow needs are related to water quality, vegetative mosaic, faunal community, boat ramp, outfitter and guide, and safety issues.

Historically, the Mississippi River meandered across the alluvial floodplain forming cut-offs and secondary channels. Secondary channels were gained and lost as the river formed new courses to the Gulf of Mexico (Williams & Clouse 2003). Levees, revetment, and dikes have stabilized the river and limited the formation of new secondary channels. Secondary channels have become a finite resource. Sedimentation and loss of connectivity with the main channel continue to reduce the quality and quantity of side channels (Guntren et al. 2012, Killgore et al. 2012, USACE 2013). The total number of secondary channels in the LMR depends on river stage. At high discharge, water moves laterally and reconnects numerous secondary or tertiary channels that are dry at lower stages.

Floodplain waterbodies are not connected to the channel when it is confined below banks. During low-water, secondary channels may remain connected to the main channel. At low water, fish and other aquatic fauna may be confined to the main channel where deep water and

high velocities can impair survival and growth. Secondary channels offer greater habitat diversity compared to the main channel (Killgore 2012, USACE 2013). Secondary channels function similarly to both main channel and floodplain habitats. There are areas of strong current with substrates of sand and gravel, and other areas of slackwater with connections to backwaters and lakes. Flowing water supports fishes such as suckers, minnows, and darters that are relatively intolerant to habitat changes. Overall habitat heterogeneity in secondary channels supports a diverse assemblage of invertebrates and fishes and contributes to the overall health of the aquatic system (Baker et al. 1991, Simons et al. 2001).

Dense alluvial clays dominate in these backwater areas that historically supported extensive wetlands. Natural levees form along the banks of the LMR. The riverbank can be 10 to 15 feet higher than the lowlands farther back from the river. Because of these natural levees, drainage within the floodplain, frequently flows away from the Mississippi River to lower elevations near the valley walls, except near tributary confluences (Kleiss et al. 2000). Slackwater areas, access to backwaters, structurally complex riverbanks, and other habitats are important for biotic integrity of aquatic communities (Killgore 2012, USACE 2013).

The endangered fat pocketbook mussel was probably common in oxbows and sloughs (Miller & Payne 2005). In the LMR, mussels are found in a mixture of sand, silt, and mud substrates in side channels (USFWS 2012). Backwaters provide nursery areas for both freshwater and estuarine fishes (Parmalee 1967, Harris & Gordon 1987, USFWS 1989, Harris & Gordon 1990, Watters et al. 2009, USFWS 2012). Many oxbow lakes are now outside of the levee system and turbidity, sedimentation, water quality, and land use impact habitat quality (Miranda & Lucas 2004).

Secondary channels support fishing, paddling, hunting and bird watching. There are 33 million anglers in the U.S., and they spend around 550 million days fishing annually. Anglers spend over $40 billion every year (USDI 2011) and support nearly 600,000 American jobs (Yellow Wood 2013). Between 2006 and 2011, the popularity of fishing rose 3%. Fishing is popular across all demographic groups – ethnicity, age, gender, and education levels. There are 1 million anglers over the age of 75. Fishing accounts for 67% of the outdoor recreational activity in the region (USDI 2011).

The LMRCC developed and continues to update the Restoring America's Greatest River (RAGR) initiative. RAGR is a plan to implement aquatic habitat restoration and river-access improvement projects within the river's active floodplain from Cairo to the Gulf of Mexico. LMRCC and its partners have identified projects to address side channels, backwaters and oxbows, sand and gravel bars, islands, and main channel habitat. LMRCC has implemented 14 projects since 2006 with cooperation from USACE, USFWS, state agencies, and the Mississippi River Trust. These projects have restored flow to 56 miles and thousands of acres of side channel habitat. These projects are valuable to pallid sturgeon, fat pocketbook mussels, interior least terns, and many other species.

Invasive Species

The habitat assessment identified a need to manage native species and control invasive species. The recreation assessment noted the importance of these species for hunting, fishing and wildlife watching. The needs for faunal communities are related to water quality, data management, tributary management, vegetative mosaic, floodplain, sandbar, island, outfitter and guide, boat ramp, interpretation, and marketing issues.

Habitat changes have affected the relative abundance of native species in the LMR. Habitat changes have driven most of the population changes for birds and mammals, but the introduction of invasive species has caused significant impacts to native aquatic species. A variety of exotic aquatic species are established in the LMR. These species disrupt native species assemblages. Predation or competition with exotic species jeopardizes almost half of the species listed as threatened or endangered in the U.S. (ANSTF 2012).

Common carp were introduced in the early 20th century and have become so well established that they are often overlooked in discussions of invasive species. The four more recently introduced carp species (bighead, black, silver, and grass) garner most of the attention and management focus, but all of the carp species have had negative impacts on native fishes (Conover et al. 2007). Bighead carp adversely impact mussels, larval fish, and several adult fishes such as gizzard shad, bigmouth buffalo, and paddlefish. Black carp pose a threat to many of the remaining populations of federally listed threatened and endangered mussels. Competition between black carp and native freshwater drum, the host for the endangered fat pocketbook mussel, is significant (Conover et al. 2007). Grass carp prefer a diet of submerged plants with soft leaves, but will also consume detritus, insects, small fish, earthworms, and other invertebrates. Grass carp can damage native aquatic vegetation. Silver carp lack a true stomach so they feed almost continuously and competition with native planktivores is a major concern (Conover et al. 2007, Fuller 2013a). The carp are also hazardous to boaters because they jump out of the water in response to boats.

Zebra mussels are very prolific and can reach high population densities (MDC 2007, Fuller 2013b). They can reduce the density of phytoplankton, which is food for many native fish and mussels. An estimated $200 million is spent annually to maintain intake pipes and screens that become clogged with zebra mussels (MDC 2007, Fuller 2013b).

The U.S. Congress passed the Nonindigenous Aquatic Nuisance Prevention and Control Act in 1990 to establish a broad national program to stop the introduction of nuisance species and control the spread of species already present. This legislation was reauthorized and expanded when the National Invasive Species Act was enacted in 1996 (ANSTF 2012). The Aquatic Nuisance Species Task Force (ANSTF) comprised of 13 Federal agencies and 13 ex-officio representatives (i.e., Mississippi Interstate Cooperative Resources Association or MICRA) is devoted to preventing and controlling aquatic invasive species (ANSTF 2012). The ANSTF Strategic Plan 2013-2017 focuses on prevention, monitoring, and control of aquatic nuisance species, and increasing public awareness of aquatic invasive species and their impacts (ANSTF 2012). Controlling nuisance species is primarily achieved through prevention, early detection,

and rapid response. Public education, awareness, and collaboration are vitally important to control aquatic nuisance species.

Sandbars and Gravel Bars

The habitat assessment identified the need to manage sandbars primarily for the benefit of the federally listed endangered least tern, but they also benefit pallid sturgeons. The needs for sandbars are related to sediment, faunal community, and side channel issues.

Gravel bar habitats are important as spawning substrate for pallid sturgeon as well as other fish species. Sandbars generally are dynamic features of the natural river landscape. Dynamic river forces form, enlarge, erode, move, and destroy sandbars. On established sandbars, high water removes existing vegetation and deposits new sand. Properly deposited dredged material can also create sandbars.

Sandbars are the primary nesting habitat for endangered interior least tern. When sandbars become fully vegetated, terns will not use them (Thompson et al. 1997). Flooding can scour vegetation from sandbars and convert them to suitable nesting habitat. If perennial woody vegetation becomes well-established and high flows can no longer remove vegetation, sandbars succeed to forest and permanently lose nesting value (Sidle et al. 1992, Friedman et al. 1998, Johnson 2000, Leslie et al. 2000, Wiley & Lott 2012). Terns do not nest in proximity to tall vegetation or other high features, or where channels become narrow (Jorgensen et al. 2012; USACE 2011).

USACE and USFWS worked together to develop the *Conservation Plan for the Interior Least Tern, Pallid Sturgeon, and Fat Pocketbook Mussel in the Lower Mississippi River (Endangered Species Act, Section 7(a)(1))*. The Endangered Species Act requires Federal agencies to use their authorities as appropriate to carry out programs for the conservation and recovery of endangered and threatened species. USACE, USFWS, and state conservation agencies identified issues associated with USACE flood risk management and navigation projects on the LMR. These projects have caused the most significant impacts to the river, but offer the best, most cost-effective tools to address these issues. USACE will incorporate ecological engineering concepts in the design of channel improvement and channel maintenance projects. This should provide localized improvements in habitat function and value, with little to no effect on flood risk management, navigation, or project cost. USACE will continue to partner with other agencies to implement cost-effective secondary channel restoration where possible. These actions have already benefitted endangered species habitat in the channel. This plan describes the programmatic mechanisms USACE can use to implement recovery and conservation measures in the Channel Improvement Program of the Mississippi River and Tributaries project.

Floodplain

The habitat assessment noted the importance of floodplain habitats for a variety of species. The needs for the floodplain are related to sediment, water quality, tributary management, vegetative mosaic, side channel, and faunal community issues.

The LMR floodplain provides valuable habitat for waterfowl, resident fish, river fish, and other wetland and other species, such as freshwater mussels. Floodplain connectivity is important for fish, aquatic insects, mussels, turtles, birds, and mammals (Winemiller 2003).The construction of the Mississippi River levee system altered natural patterns of surface water drainage within the region and reduced the floodplain area over 80% (Baker et al. 1991). Fish and other aquatic species no longer have access to millions of acres of foraging, spawning, and nursery habitat. Mississippi River water no longer spreads out over the historic floodplain. There is less opportunity for nutrients to attenuate and for water to percolate through the soil (Winemiller 2003). Wetland quantity and quality has been reduced in the region.

The remaining floodplain with its backwater areas is a dynamic freshwater ecosystem. The active LMR floodplain varies in width from 1 to 15 miles. The nearly 3 million-acre floodplain is interspersed with abandoned channels, meander scars, borrow pits, and large expanses of forested wetlands, and tributary mouths (Baker et al. 1991). These areas provide a diverse array of aquatic habitat types and are connected to the river at high water. Flooding is necessary about once every two years to maintain populations of some fish and lack of flooding may result in successive reproductive failures (Barko et al. 2006). Changes in timing and extent of flooded acreage affect migratory waterfowl and shorebirds. The floodplain, at high water, provides nutrition, secure roosting, cover in inclement weather, loafing sites, protection from predators, and isolation for pair formation.

The floodplains of tributary rivers may have become more important since the Mississippi River floodplain has been reduced. Cities, farms, highways, factories, and other developments have moved into the historic floodplain. Opportunities to restore land to the floodplain will likely be rare and small scale. On the main stem Mississippi River, restoration efforts should focus on restoring the quality of habitat within the batture as discussed in the vegetative mosaic and side channels, backwaters and oxbows sections.

Islands

The habitat assessment identified the need to inventory islands to determine their ecological value. Islands are related to data management, vegetative mosaic, side channel, and faunal community issues.

Mississippi River islands are unique habitats. Islands afford many species safe places for sensitive life cycle events such as nesting. There is a need for an ecological inventory of islands in the LMR to determine their value for habitat and potential for restoration. At least two Mississippi River islands have been offered for sale in the last two years. State, federal or non-governmental conservation organizations have shown some interest in acquiring these, but there is not enough information about their ecological value.

RAGR includes some island conservation opportunities.

Coastal Wetlands

Although coastal wetlands are dependent on fresh water and sediment from the river, they are outside of the project area, and this report includes no recommendation for them. Any program to manage water quality and better understand sediment will benefit coastal management. Preserving and rebuilding coastal wetlands is a recognized need. Congress authorized the Louisiana Coastal Area program in 2007 and Louisiana's Comprehensive Master Plan for a Sustainable Coast sets forth a long term plan to address coastal needs.

Main Channel Habitat

The habitat assessment identified a need to provide some habitat diversity in the main channel. The recreation assessment mentioned the popularity of fishing and boating in the channel and the safety concerns associated with it. The main channel needs are related to sediment, water quality, tributary management, side channel, sandbar, island, outfitter and guide, boat ramp, riverboat landings, and safety issues.

Habitat in the main stem of the Mississippi River is less diverse than it was historically. Channel cut-offs reduced the number of bendways, which shortened the river causing a major loss in channel habitat including pointbars and gravel bars. Dike fields and the associated sediment accretion between dikes reduce aquatic surface area. However, dikes associated with outside bends often scour sediments and increase pool habitat. Revetment construction has reduced naturally steep banks (Baker et al. 1991). However, channel habitat and transitional areas between the thalweg and shoreline (i.e., channel borders) have persisted over time and continue to provide habitat diversity in the main stem LMR.

Pallid sturgeons occupy the deep water of large, turbid rivers, particularly the main channel (Kallemeyn 1983). They mostly occupy the sandy main channel, but are also found over gravel substrates (USFWS 1993; Bramblett & White 2001; Hurley et al. 2004; Garvey et al. 2009; Koch et al. 2012). Much of the natural habitat throughout the range of pallid sturgeon has been altered and this is thought to have had a negative impact on this species (USFWS 1993). Habitats were once very diverse, and provided a variety of substrates and flow conditions (Baker et al. 1991; USFWS 1993). Extensive modification of the Mississippi River over the last 100 years has changed the form and function of the river (Baker et al. 1991; Prato 2003). Today, habitats are reduced and fragmented; and much of the Mississippi River basin has been channelized to aid in navigation and flood risk management (Baker et al. 1991). The impact of habitat alteration on pallid sturgeon throughout its range is unknown, but recent studies have shown suitable habitat is available (USFWS 2007).

There is a need to restore some of the diversity in the main channel of the Mississippi River in areas where it is compatible with navigation. The Restoring America's Greatest River initiative and the Conservation Plan for the Interior Least Tern, Pallid Sturgeon, and Fat Pocketbook Mussel in the Lower Mississippi River both include opportunities for restoring some of this habitat.

Outfitters and Guides

The recreation assessment identified a need for more outfitters and guides. Outfitter and guide companies can benefit from more boat ramps, well managed habitats, information services, marketing and interpretation. Although there are world-famous tourist destinations in the region, the river itself has not been marketed as a destination. New initiatives to draw people to the region will create opportunities for outfitters and guides. Many visitors to the region may be interested in spending a day bird watching, bicycling, fishing or canoeing in the area, and will need equipment, transportation, guides and other services. Outfitters and guides can help people with varying abilities enjoy the river safely.

Boat Ramps

The recreation assessment identified the need for more and better boat ramps on the river. Boat ramps are related to side channel, main channel, outfitter and guide, and safety issues.

There are 129 boat ramps on the LMR. Many of the ramps are located in fast water areas near the commercial navigation channel and are not safe for smaller craft including canoes. More boat ramps located near side channels and back channels would encourage more and safer river use for paddling, fishing and general boating. Canoes and kayaks can be launched anywhere with a parking area, access to the water's edge and a gentle slope into the water. Motorboats require a hardened boat ramp and a larger parking area to accommodate trailers.

The Louisiana Department of Wildlife and Fish found that there are not many safe and suitable public launches into the Mississippi River south of Baton Rouge. The few that do exist do not offer safe harbor/docking facilities for boats at various river stages. River stages change substantially with season and engineering "safe harbors" for boats at various river stages is difficult. LDWF has received several requests from the public for suitable launches and docking facilities for boats into the Mississippi River at various locations in Southeast Louisiana.

There are 24 million paddlers in North America and the popularity of kayaking is growing. Paddling generates over 300,000 American jobs (Yellow Wood 2013). Paddling canoes and kayaks is becoming more popular in the area. Non-local paddlers spend an average of $503 per excursion and anglers spend $1,261 every year (Yellow Wood 2013). Anglers spend over $40 billion every year (USDI 2011) and generate nearly 600,000 American jobs (Yellow Wood 2013). Fishing accounts for 67% of the outdoor recreational activity in the region (USDI 2011), and many local communities depend on the money it generates for public and private income.

Additional ramps on the Mississippi River and some larger tributaries will increase access and safety and provide more opportunities for recreational paddlers and fisherman as well as outfitters and guides. The Restoring America's Greatest River initiative includes proposals for boat ramps.

Riverside Parks

The recreation assessment identified the need for more riverside parks in local communities and noted they would be good places for interpretation.

There is a need to improve undeveloped riverfront areas in many towns along the Mississippi River. A few simple improvements could increase the usability of these areas; namely designated parking, shelters, picnic tables, and routine mowing and trash pickup. Local residents would appreciate these small gathering spots and they would provide excellent venues to teach people about the river. Informational signs could offer historical information as well as information about navigation and flood risk management on the river.

Riverboat Landings

The recreation assessment identified a need for better riverboat facilities. The popularity of riverboat cruises is related to marketing and interpretation.

Port to port river cruises are again becoming popular on the Mississippi and worldwide. Over the past five years, international river cruises have enjoyed a 10% passenger increase. In 2011, the American Queen rejoined the Queen of the Mississippi to provide river cruises. Efforts are underway to return the Delta Queen to service and Viking River Cruises, well-known for European river cruises, has announced plans to come to the Mississippi River (Sullivan 2013).

The river cruises offer views of the wilderness, bluffs, historic cities and towns, and the river itself that are not seen from anywhere else. The riverboats dock at many towns along the river. These stops offer excursions for historic tours, nature tours, music shows, or culinary events depending on the area. Many small towns have inadequate facilities for the riverboats to dock and allow passengers of varying physical abilities to disembark. Riverboats stop at Columbus, KY to tour the Civil War Battlefield at Columbus-Belmont State Park, but there is no developed dock or tie off for the boat. Helena, AR lost revenue during the high water in 2011 and the extreme low water in 2012 because the river boats could not dock there. Chamber of Commerce representatives up and down the river envision future facilities that would ensure more consistent access for passenger vessels. These landings can incorporate restaurants and interpretive facilities and become community assets beyond being riverboat docks. For example, Beale Street Landing in Memphis links the world famous blues district with the Mississippi River.

Lodging and Dining

The recreation assessment identified a need for more lodging and dining in the region. This need is related to the need for better marketing of river attractions.

Lodging and dining are readily available along the interstate highway corridors, but are generally lacking along the more rural routes including the Great River Road National Scenic Byway. Agricultural land dominates the area, and there are few commercial developments to provide lodging, camping, food, or other services. There is a need for a variety of lodging types including RV parks, family motels, and bed and breakfast inns. Long distance bicyclists, people

experiencing the various Native American sites, touring Civil War sites and others would all benefit from more lodging options (Yellow Wood 2013).

Bicycle Trails

The recreation assessment identified a need for more bicycling trails. There are bicycle rental shops in downtown Memphis and New Orleans that provide equipment for riding around downtown areas. The expansion of levee trails in Louisiana, the Big River Parkway from New Orleans to St. Louis, and the completion of the Harahan Bridge project at Memphis will spur more opportunities for bicycling in the region. Tourists who come to the region for festivals, bird watching, and family vacations may be interested in renting bicycles for day trips across the river or along the levees. Use of the Mississippi River Trail for multi-day rides would likely expand if lodging and dining facilities were available closer to the trail.

There are 60 million American bicyclists. Bicycling is popular across all demographic groups – ethnicity, age, gender, education, and economic status. Recreational bicycling generates 1.1 million American jobs (Yellow Wood 2013). Americans spend more money every year on bicycling gear and trips ($81 billion) than they do on airplane tickets and fees ($51 billion) (OIA 2012). Bicycle trails and lanes in the major metropolitan areas are expanding. As bicycling is becoming more popular, the demand for linking existing trails and creating longer routes is growing.

Interpretation

The recreation assessment identified a need for more interpretation of the river and its resources. The need to provide the public with more information about water quality and the other natural resources of the river was noted previously. This need is related to water quality, data management, faunal community, boat ramp, park, riverboat, bicycling, and marketing issues. Interpretative signs can be a feature of any recreation facility.

Although the Mississippi River watershed drains all or parts of 31 states and 2 Canadian provinces and is the third largest watershed in the world, there is very little information provided to tourists or potential visitors. There are no signs to tell the public that the river creates $105 billion worth of U.S. Gross Domestic Product; provides drinking water for more than 18 million people; transports 62 percent of our nation's agricultural output; delivers nearly 400 million tons of coal and petroleum products annually; and directly supports one million jobs and indirectly supports millions more.

The Mississippi River and Tributaries Project levees, floodwalls, backwaters and floodways form the world's largest and most comprehensive flood risk management system. The 2011 Flood drew national and international media attention and travelers in the area stopped to take a look at the river where they could. There is a need for signs and brochures for the public that explain and describe levees, floodwalls and features of the system that protects 1.5 million homes and other structures, and, in 2011 alone, prevented $234 billion in damages.

Marketing

The recreation assessment identified a need for a comprehensive marketing program for the LMR. The need for marketing is related to water quality, data management, faunal community, outfitter and guide, boat ramp, riverboat, lodging and dining, bicycling and interpretation issues.

The Mississippi River Parkway Commission manages the Great River Road. Its website (experiencemississippiriver.com) offers a lot of information to help travelers plan trips, but there is a lot of information missing. There is also a need for more cross marketing to reach people who come to the area for a particular event, but might be interested in other activities if information is readily available. The National Geographic Society Geotourism Destination project may provide the needed marketing for the Mississippi River corridor.

GPS navigation units are becoming standard for most travelers. People depend on them to find hotels, restaurants, and other attractions. Scenic byways are not part of the standard package in most units, but some do have the option of downloading more features. The Great River Road is not a single highway route and can be difficult to follow if the roads signs are missing or not visible. GPS units are not programmed to follow the route. There are two commercial companies that collect and update the information available on navigation units. Marketing the LMR should include a dedicated effort to get its motor routes and attractions listed.

Safety

The information and recreation assessments both identified a concern about safety on the Mississippi River. Safety concerns are related to recreational uses of the river and should be considered in the development of new facilities.

Safety can never be taken for granted especially around water and on roadways. There is a constant need for programs to teach water safety, safe boating, life jacket use, helmet use, and rules of the road for bicyclists and drivers. Although water quality in the river is generally good and contact is unlikely to cause harm, people should be reminded that drinking the water from any stream or river is not safe. The message of the safety programs needs to compliment marketing information to let people know there are many recreational activities which can be safe if the proper precautions are taken.

The U.S. Coast Guard keeps records of accidents and provides safety training and information for boaters to avoid accidents. There were four collisions on the LMR in 2011 involving recreational vessels, three in Illinois and one in Missouri. All of these accidents involved motorized watercraft. There were no collisions on the river between recreational and commercial vessels. The location of boat ramps is a concern; many ramps are located in swift water areas very close to the commercial navigation channel. These ramps are less safe and usable for smaller crafts including canoes, kayaks, jon boats, and others with small engines. Most of the recreational users want to access the quieter side channel and back water habitats, but have to cross the navigation channel to reach those areas.

On-road bicycling with traffic can be dangerous. Quieter, less used roads in rural areas are preferred over main roads, but there is often a lack of services for emergencies and poor cell phone coverage. Bicyclists are safest on dedicated trails that have moderate bicycling traffic and services at frequent intervals. Programs to encourage helmet use and teach road sharing for both bicyclists and motorists are needed.

IV. RECOMMENDATIONS

The Mississippi River Commission's 200-year working vision for the Mississippi River seeks to leverage local citizens' input, international dialogue, science, engineering, technology and public policy to meet the Nation's needs for our largest river.

Lead secure lives along the river or tributary.

Enjoy fresh air and the surrounding fauna, flora, and forests while hunting, fishing, and recreating.

Travel easily, safely, and affordably.

Drink from and use the abundant waters of any river, stream, or aquifer.

Choose from an abundance of affordable basic goods and essential supplies that are grown, manufactured, and transported along the river to local and world markets.

Throughout public scoping and the development of the three needs assessments, the team, including USACE, USFWS, The Nature Conservancy, National Audubon Society, Mississippi River Corridor –TN, and LMRCC (representing the natural resource agencies in AR, KY, LA, MO, MS, and TN), met with the public, private businesses, National Park Service, Mississippi River Parkway Commission, USDA, and many other entities. This interagency team examined existing plans, programs, missions, and authorities related to the identified needs. The recommendations were formulated to work in concert with the ongoing initiatives to improve and promote the Lower Mississippi River for its ecological and cultural value

This assessment recommends the creation of three interconnected programs for the Lower Mississippi River that will further the goals of the vision. The success of these three programs will rely on interagency coordination, and public private partnerships. Within these three overall programs, there are recommendations for specific projects and studies. Each of these recommendations includes a description of what is being proposed, what agencies or entities are most appropriate to implement the action, which of the needs in the previous chapter the recommendation addresses, how much it is likely to cost and the value to the nation of addressing the needs. Each recommendation can be implemented as a standalone project, but many of them are interrelated and more benefits will accrue if they are implemented as a comprehensive program.

DATA, INFORMATION, SCIENCE AND COMMUNICATION PROGRAM

The Mississippi River is one of the nation's greatest assets. There are Federal agencies, state agencies, county and parish governments, cities, towns, non-governmental organizations, and commercial enterprises involved in projects and initiatives on the river. These entities have overlapping information needs. A Data, Information, Science and Communication (DISC) Program for the LMR is necessary to support the next 200 years of Mississippi River management. The following four recommendations define this DISC program.

Science, Technology and Information Center

Recommendation DISC 1: Create a Lower Mississippi River Information Center (LMRIC) to collect and store information about the LMR including: historical information, scientific data, management, and use. The LMRIC would locate all available information, perform quality assurance of the data and make it available online and in house. The LMRIC should be open to agencies, universities, researchers, users and the general public. The LMRIC would also be a resource for river education outreach projects and science, technology, engineering and math career outreach.

Lead Organization and Partners: The USGS should be funded to lead an interagency working group including USACE, EPA, NPS, USFWS, state agencies and others to develop a plan for the LMRIC that addresses location, management, long-term funding, and other specifics. All of the above mentioned agencies would need to commit to providing existing and future agency data to the LMRIC.

Needs Addressed: This recommendation directly addresses the need for better Data Storage and Availability. It would also be useful in addressing needs for better management of Water Quality, Sediment, Vegetative Mosaic, Invasive Species, Floodplain, Islands, Outfitters and Guides, Interpretation, Marketing and Safety.

Cost: The annual operating budget for the Upper Mississippi River Long Term Resource Monitoring Program on the Upper River includes approximately $2,000,000 a year for staff and overhead. The recommended center of the Lower River would have a broader mission, but costs would be similar.

Value: The LMRIC would be critical to leverage science, engineering, technology and public policy to meet the Nation's needs for our largest river. It would promote interagency cooperation, encourage research and foster public interest in the river.

Sediment Study

Recommendation DISC 2: Continue with sediment analysis of the Middle and Lower Mississippi River that was initiated in 2014 in a Mississippi River Geomorphic and Potamology Study. The analysis will determine sediment sources, sizes, quantities, fates, and transport parameters. It will build on the ongoing work in the Mississippi River Hydrodynamic and Delta Management Study and the work of the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force.

Lead Organization and Partners: USACE initiated these studies under the Mississippi River and Tributaries Project and the Louisiana Coastal Area Mississippi River Hydrodynamic and Delta Management studies. USGS is also participating in these studies.

Needs Addressed: This recommendation directly addresses the need for Sediment Management. It would also be useful in addressing Water Quality and Sandbars and Gravel bars.

Cost: The current studies have an annual cost of approximately $4,000,000. Ongoing studies would be expected to have similar costs.

Value: Understanding sediment dynamics is important for river management. Sediment management plans are in place for many of the world's great rivers: the Rhine (Europe), the Blue Nile (Africa), the Yangtze (Asia), the Columbia (North America), and the Darling (Australia). These plans are benefitting coastal areas, navigation, hydropower, and land conservation around the world. USACE spends up to $170 million annually dredging sediment in the Lower Mississippi River to maintain the navigation channel. Plans for the restoration of coastal wetlands in Louisiana call for more than $25 billion to be spent on a variety of projects, most involving water and sediment management.

Water Quality Monitoring Program

Recommendation DISC 3: Create a dedicated water quality monitoring program for the entire LMR. The new program should standardize collection techniques, timing, methodology and parameters. The data should be useful for developing localized, point-in-time water quality assessments and long term trend monitoring. Existing water quality information should be archived in the LMRIC. The LMRIC would be a valuable asset to support this program and assessments of historic water quality changes.

Lead Organization and Partners: This water quality monitoring program would exceed the capacity of any one agency to develop and manage. The USGS and EPA should lead the effort to create a comprehensive water quality monitoring program. USACE, USFWS, NOAA, the twelve states and the National Tribal Water Council that are part of the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force should also be part.

Needs Addressed: This recommendation directly addresses the need for better Water Quality monitoring. The information generated would be important to recommendations for Data Storage and Availability, Sediment, Tributary Management, Vegetative Mosaic, Invasive Species, Floodplain, Interpretation, and Safety.

Cost: The Long Term River Monitoring Program for the Upper Mississippi spends approximately $2,000,000 annually for water quality monitoring including fish sampling and aquatic vegetation surveys. The LMR program would have similar costs.

Value: A water quality monitoring program would insure the Mississippi River provides good water for drinking, recreating, and industry. Water quality is important for the river itself, coastal wetlands, fish, wildlife, water supply, groundwater, Gulf of Mexico hypoxia, recreation, and tourism. Clean water is vital to the economy of the nation and the quality of life in the lower Mississippi River Valley. The Gulf of Mexico hypoxic zone sits atop one of the most productive fisheries in the world, and the ecological and economic impacts of hypoxia are under study.

Tributary Watershed Studies (DISC 4)

Recommendation DISC 4a: Conduct Comprehensive Watershed Studies of the major tributary rivers of the LMR as authorized in Section 729 of the Water Resources Development Act of 1986. The following watersheds have been identified as priority watersheds:

Bayou de Chien – Mayfield Creek, KY
Obion River, TN
Forked Deer River, TN
Hatchie, River, TN
Bayou Pierre, MS
Big Black, MS

These watersheds were chosen because they have not received large scale water resources planning; they contain unique resources; there are opportunities for public private partnerships to foster water resource management; there are problems and opportunities in the watershed that a comprehensive study could address; they are important to water quality and sediment management in the river; and they have the potential to provide valuable habitat and recreation connected to the Mississippi River. The USACE districts and potential local sponsors have previously discussed the potential for most of these studies and some have been included in budget requests. There are other LMR watersheds that may also possess these characteristics, and comprehensive studies could be done on them as well. Appendix A contains maps of each watershed listed above.

Lead Organization and Partners: USACE would lead these studies under Section 729 of WRDA 1986. Partners would vary by watershed but would likely include USFWS, USDA, state resource agencies, and NGOs.

Needs Addressed: This recommendation directly addresses the need for better Tributary Management. Tributary Management will be important in addressing needs for Water Quality, Sediment, and Floodplains and may provide opportunities to meet needs for Boat Ramps and Bicycle Trails.

Cost: These studies would vary from approximately $1,000,000 for the smaller watersheds up to $5,000,000 for the largest.

Value: The Mississippi River cannot be separated from its tributaries. They are the source of water, contaminants, nutrients, and sediment. They provide important habitat for fish and wildlife and provide recreation opportunities. Studies on the basins recommended would provide the information necessary to manage these watersheds to provide benefits locally and to the Mississippi River as a whole.

Recommendation DISC 4b: Conduct studies on larger tributary systems. These studies would focus on the active floodplain and existing water resources infrastructure and not on the entire watershed. USACE would need specific authorization to conduct these studies.

Recommendation DISC 4b.1 St. Francis Basin

Lead Organization and Partners: USACE would lead the study with participation from USDA, St. Francis Levee and Drainage District, Arkansas state resource agencies, and others.

Cost: $3,000,000

Recommendation DISC 4b.2 Arkansas River

Lead Organization and Partners: USACE would lead the study with participation from state and federal agencies in Arkansas, Oklahoma, Kansas and Colorado.

Cost: This study would be expected to cost between $5,000,000 and $7,000,000.

Recommendation DISC 4b.3 Ouachita River

Lead Organization and Partners: USACE would lead the study with the Ouachita River Valley Association.

Cost: $3,000,000

These three rivers were chosen because they contain water resources infrastructure critical to the Mississippi River. Each one is unique in its needs and contributions to the Mississippi River. USACE is in ongoing discussions with the existing sponsors of water resources projects on these tributaries and the potential for further studies has been previously discussed. Appendix A contains more information for each river.

Ecological Inventory (DISC 5)

Recommendation DISC 5a: Island Inventory - Conduct an ecological survey of the islands on the Mississippi River to determine their uniqueness, ecological resources, and opportunities for restoration.

Lead Organization and Partners: With the approval of the landowners, the USGS and the USACE Engineer Research and Development Center should conduct the survey in cooperation with the USFWS.

Needs Addressed: This recommendation directly addresses the need for better information about Mississippi River Islands.

Cost: $500,000

Value: The ecological inventory of islands in the LMR would determine their value for habitat and potential for restoration.

Recommendation DISC 5b: Potential Natural Vegetation Study – Conduct research on the current hydrology, soils, and historic vegetation within the batture and develop a potential vegetation map to inform vegetative restoration.

Lead Organization and Partners: The USFWS could lead this effort as part of the National Wetlands Inventory or the Engineer Research and Design Center (ERDC) could lead the study in support of existing projects.

Needs Addressed: This recommendation directly addresses needs for restoring the Vegetative Mosaic and improving the quality of Floodplain habitat.

Cost: $1,200,000

Value: This information would be provided to landowners, non-governmental organizations, and agencies interested in restoring the vegetative mosaic of the valley.

HABITAT RESTORATION and MANAGEMENT PROGRAM

The Mississippi River Valley covers around 25 million acres (Saucier 1994). Historically, bottomland hardwood forests, swamps, marshes, and oxbow wetlands covered most of the valley. The LMR had a sinuous course with numerous meander loops, bends, and oxbow lakes (Baker et al. 1991) and shifted its channel frequently reworking parts of its alluvial meander belt (Saucier 1994, Amoros & Bornette 2002). These diverse habitats supported a rich biotic community including reptiles, amphibians, fish, freshwater mussels, birds, mammals, and plants.

Over the past 150-200 years, the alluvial valley, floodplain, and channel of the LMR have been altered (Baker et al. 1991). Forests have been cleared and drained for agricultural, municipal, residential, and industrial purposes. Levees reduce flooding in most of the valley and the channel has been realigned and constrained.

At least 90 species of freshwater fish (Baker et al. 1991) and around 50 species of mussels (Jones et al. 2005 & USACE records) are found in the LMR. Over 300 species of birds use the Mississippi River valley (Scott ed. 1983). The Mississippi Flyway is an important corridor for migratory waterfowl, shorebirds, and Neotropical migratory birds that require feeding and resting habitat during spring and fall migrations. Nearly 40% of North America's waterfowl and 60% of all bird species in the US migrate through the valley (Scott ed. 1983).

There are a variety of federally listed threatened and endangered species which are known or believed to occur in the LMR or its tributaries. They include mussels (Alabama heelsplitter, fat pocketbook, Louisiana pearlshell, scaleshell, rabbitsfoot), plants (decurrent false aster, Geocarpon minimum, pondberry), birds (interior least tern, red-cockaded woodpecker), mammals (Indiana bat, Louisiana black bear), and fish (pallid sturgeon, relict darter). The USFWS developed Recovery Plans detailing the life history, habitat needs, threats, and status for all of these species.

The LMRCC is a coalition of 12 state natural resources conservation and environmental quality agencies from Arkansas, Kentucky, Louisiana, Mississippi, Missouri and Tennessee. It provides the only regional forum dedicated to conserving the natural resources of the Lower Mississippi River floodplain. LMRCC focuses on habitat restoration, landscape level conservation planning, and natural resource-based economic development. USFWS leads the effort and provides a full time coordinator. USGS, USACE, EPA, and NRCS are cooperating agencies. The LMRCC coalition will be crucial to the success of any habitat program on the Lower River.

Conservation Reach Studies

Recommendation HRMP 1. Conduct eight conservation reach habitat restoration studies on the LMR. The Mississippi River ecosystem is a dynamic system with interactions among the terrestrial and aquatic systems, main channel and side channel areas, mudflats, backwaters, tributaries, and islands. These feasibility studies would examine the Mississippi River and batture to determine if there is Federal interest sufficient to justify construction of ecosystem restoration features. Eight reaches have been identified as priorities.

Wolf Island to Island 8 Reach RM 946 – 910 (36 mi.)
Hatchie/Loosahatchie Reach RM 775 – 736 (39 mi)
Islands 62/63 Reach RM 650 - 618 (32 mi.)
Arkansas River Reach RM 599 – 556 (43 mi.)
Possum (Worthington-Pittman) Reach RM 524 – 490 (34 mi.)
Palmyra River Reach RM 431 – 398 (33 mi.)
Lake Mary Reach RM 360 -322 (38 mi.)
Raccourci Cutoff Reach RM 300 -265 (35 mi.)

These reaches were chosen because they may provide valuable habitat for rare species; they each contain a channel crossing; the batture is wide in the reach; and there is a concentration of previously identified potential projects. ERDC identified the Islands 62/63 Reach in 2013 as a priority in 2013 and has already begun in depth geomorphic, sediment, hydraulic and biological surveys in the reach. Several of the reaches coincide with those the USACE Interior Least Term Working Group identified as priorities. ERDC and USFWS personnel participated in the selection of the reaches. Appendix B contains maps and more detailed descriptions of each reach.

Lead Organization and Partners; USACE would need specific authorization for this priority reach habitat program. Each reach study would be conducted separately and would require non-Federal sponsors and cooperation with other Federal agencies like the USFWS and USDA. The studies should also consider restoration of upland habitats within the batture that are outside of the USACE ecosystem restoration mission. LMRCC's Restoring America's Greatest River (RAGR) initiative has already identified 104 potential projects that fall within these reaches.

Needs Addressed: This recommendation directly addresses needs for restoration of Side Channels, Backwaters and Oxbows, Sandbars and Gravel Bars, Main Channel Habitat, Vegetative Mosaic, Floodplain and Island habitats. It will also be useful in addressing needs for Water Quality, Sediment, Data Storage and Availability, Invasive Species, Boat Ramps and Safety.

Cost: $3,000,000 per study

Value: Each reach has opportunities to enhance a broad spectrum of features, i.e. restorable side channels, backwaters, and oxbows, a wide floodplain, large islands, populations of threatened and endangered species, and sandbars. These eight reaches total 290 miles or nearly 30% of the LMR. These studies would consider recreation features along with ecosystem restoration.

Aquatic Habitat Restoration Studies

Recommendation HRMP 2. Conduct aquatic habitat restoration studies in areas outside the eight reaches mentioned above. Appendix C lists 125 projects that could be studied under one of two existing programs.

> **Recommendation HRMP 2a.** Conduct Aquatic Habitat Ecosystem Restoration studies using the existing USACE authority under Section 1135 of the Water Resources Development Act (WRDA) of 1986 or Section 206 of WRDA 1996. This program has already been used to restore habitat on the LMR, e.g. Tunica Lake.
>
> *Lead Organization and Partners:* USACE has the authority to conduct these studies at the request of a non-federal sponsor, i.e. a state or local agency or non-governmental organization.
>
> *Needs Addressed:* This recommendation directly addresses needs for restoration of Side Channels, Backwaters and Oxbows, Sandbars and Gravel Bars, Main Channel Habitat, and Island habitats. It may also be useful in addressing needs Boat Ramps and Safety.
>
> *Cost:* The Water Resources Reform and Development Act (WRRDA 2014) set a total per project federal cost limit of $10,000,000 for these two authorities; approximate total cost with cost share match is $15,000,000. Many of the listed projects can be completed for less than the limit, e.g. Tunica Weir Section 1135 was completed in 2005 for less than $1,500,000.
>
> *Value:* These projects have the potential to restore important habitat.
>
> **Recommendation HRMP 2b.** Use the existing USFWS National Fish Passage Program to restore side channels and other aquatic habitat on the Mississippi. This program has already been used to restore 56 miles of habitat on the LMR.
>
> *Lead Organization and Partners:* LMRCC and the USFWS are the lead agencies. Fish Passage projects require a cost-sharing partner which can include private individuals; Federal, tribal, state, and local governments and agencies; and non-governmental organizations.
>
> *Needs Addressed:* This recommendation directly addresses needs for restoration of Side Channels, Backwaters and Oxbows, Sandbars and Gravel Bars, Main Channel Habitat, and Island habitats. It may also be useful in addressing needs Boat Ramps and Safety.
>
> *Cost:* Projects implemented through the Fish Passage Program average approximately $200,000 each.
>
> *Value:* These projects have the potential to restore important habitat.

Terrestrial Habitat Program

Recommendation HRMP 3: Terrestrial Habitat Program – Continue to implement programs that restore native vegetation to the batture. Most of the land within the batture is in private ownership. There are programs to assist landowners interested in reforestation.

Lead Organization and Partners: The NRCS provides technical and financial assistance to landowners for water quality and wetlands improvement projects. NRCS has established the Mississippi River Basin Healthy Watersheds Initiative to improve the health of the Mississippi River Basin. Through this Initiative, NRCS and its partners help producers in selected watersheds in the Mississippi River Basin voluntarily implement conservation practices that avoid, control, and trap nutrient runoff; improve wildlife habitat; and maintain agricultural productivity.

The Lower Mississippi Valley Joint Venture (LMVJV) is a self-directed, non-regulatory private, state, and Federal conservation partnership. LMVJV's goal is sustaining bird populations and their habitats within the Lower Mississippi Valley and West Gulf Coastal Plain regions. They implement and communicate the goals and objectives of relevant national and international bird conservation plans (LMVJV 2002). The Lower Mississippi Valley Joint Venture Plan was formulated to address problems that traditionally confronted wetland conservation in the region; namely, clearing of forests for agriculture and extensive alterations of wetland hydrology resulting from basin-wide flood control and drainage. In an effort to further refine its conservation delivery infrastructure, the LMVJV partnership has chartered the development of geographically-explicit Conservation Delivery Networks as the forum for coordinating its on-the-ground actions. There are four networks overlying the Lower River.

Needs Addressed: This recommendation directly addresses needs for restoration of the native Vegetative Mosaic and quality Floodplain habitat. It would also be important for managing Water Quality.

Cost: The Wetlands Reserve Enhancement Program, part of the agency's Wetlands Reserve Program, provides the funding. Between 2010 and 2013, the NRCS has formalized agreements with 47 landowners in the basin, investing $17.8 million in long-term conservation easements and wetland restoration projects.

Value: The initiative targets restoration of over 11,000 acres of wetland habitat and will prevent sediment and nutrients from entering waterways, decrease flooding, and improve bird and fish habitat. Approximately two thirds of the work is within the batture.

Invasive Species Program

Recommendation HRMP 4: Invasive Species - There are several plans in place to address invasive species on the river. Many of the species do not directly affect habitat, but they do impact native populations. Privet should be addressed site-specifically when developing forest restoration plans. USDA is doing research on kudzu control in the south. This research and control programs should continue. The Aquatic Nuisance Species Task Force (ANSTF) and

Mississippi Interstate Cooperative Resource Association (MICRA) have both developed plans to manage and control carp and other aquatic nuisance species. These plans should be implemented.

Lead Organization and Partners: Both MICRA and ANSTF are interagency organizations. Implementing the aquatic nuisance species plans will require cooperation between the states and USFWS. Other agencies will play a role in limiting the spread of species.

Needs Addressed: This recommendation directly addresses needs to manage Invasive Species. It will be important for restoring habitat quality in the Floodplain and reestablishing a native vegetative mosaic.

Cost: MICRA's *An Action Plan to Minimize Ecological Impacts of Aquatic Invasive Species in the Mississippi River Basin* estimates federal funding needs at $104,450,000 annually. This is a comprehensive plan for the entire Mississippi River Basin. The plan increment for the Lower Mississippi River is a small piece of the total.

Value: Invasive species have entered, and continue to enter and spread within the United States from a variety of sources. The strategy would minimize risk of new introductions and focus effort on containing and controlling established populations. Reducing the impact of invasive species will benefit native aquatic resources within the Basin.

RECREATION PROGRAM

Recreation and tourism are important economic sectors in the LMR. Outdoor recreation in the region generates over $1.3 billion in direct revenues and employs nearly 55,000 people. Tourism in the area generates $15.5 billion in direct revenues and employs over 190,000 people.

The Mississippi River Parkway Commission (MRPC) works collaboratively with other entities to promote travel to the Mississippi River, Great River Road National Scenic Byway and the surrounding ten states: Minnesota, Wisconsin, Iowa, Illinois, Missouri, Kentucky, Tennessee, Arkansas, Mississippi and Louisiana. It was established in 1938 to preserve, promote, and enhance the scenic, historic, and recreational assets of the Great River Road National Scenic Byway and foster economic growth in the corridor.

Within the U.S. Department of Transportation, the Federal Highway Administration (FHWA) has responsibility for the National Scenic Byways Program. The Program is a grassroots, collaborative effort established to help recognize, preserve and enhance selected roads throughout the United States. The Secretary of Transportation recognizes certain roads as America's Byways® - All-American Roads or National Scenic Byways - based on one or more archaeological, cultural, historic, natural, recreational and scenic intrinsic qualities. The law guiding implementation of the National Scenic Byways Program is in Section 162, Title 23 of the United States Code; 23 U.S.C. 162.

The Secretary of Transportation makes grants to States and Indian tribes to implement projects on highways designated as National Scenic Byways or All-American Roads, or as State or

Indian tribe scenic byways. Projects submitted for consideration should benefit the byway traveler's experience, whether it will help manage the intrinsic qualities that support the byway's designation, shape the byway's story, interpret the story for visitors, or improve visitor facilities along the byway.

The National Park Service's Rivers Trails and Conservation Assistance (RTCA) program extends and expands the benefits of the National Park Service throughout the nation. They help connect all Americans to their parks, trails, rivers, and other special places. When a community asks for assistance with a project, RTCA staff provides free, on-location facilitation and planning expertise. RTCA helps guide a project from conception to completion. RTCA draws from project experiences across the country and adapts best practices to a community's specific needs. The Mississippi River Connections Collaborative (MRCC) is a part of the RTCA.

The mission of the MRCC is to promote the magnificence and diversity of the Mississippi River as a national treasured landscape. This joint effort works to increase recognition of America's Great River, enhance the existing resources, acquire funding for conservation, and ensure that all Americans can enjoy these assets in the future. The MRCC coalition will be crucial to expanding recreation and tourism on the LMR.

Boat Ramps

Recommendation RP 1. Boat Ramps – Increase the number of boat ramps on the LMR. A boat ramp every 10 to 20 miles on the river would provide more opportunities for paddlers, fishermen and hunters and would increase the ability to conduct search and rescue operations. More ramps should be available to directly access backwaters and side channels. Ramps also provide locations for interpretive signs about the Mississippi River, environmental education and safety.

Lead Organization and Partners: LMRCC identified 23 potential boat ramps in RAGR. Local governments and private landowners could get permits from USACE and develop free or for profit ramps. RCTA and National Scenic Byway Grants may be available to help local communities plan and build boat ramps. Boat ramps may be added to other USACE projects under certain conditions, but this option will likely not provide enough ramps to meet the needs of recreational users.

Needs Addressed: This recommendation directly addresses needs for more Boat Ramps and will help address needs for improved Safety.

Cost: Variable depending on size and location; $50,000 - $750,000 each

Value: Boat ramps would provide recreational opportunities for paddlers, anglers, duck hunters and bird watchers. These users spend millions of dollars annually in the region and support manufacturing jobs nationwide. Existing ramps launch boaters into the main navigation channel. Ramps designed and located for recreational use would be safer and encourage people to recreate in the calmer side channel and backwater areas.

Bicycle Trails

Recommendation RP 2. Bicycle trails – Increase the total mileage of bicycle trails and especially trails where vehicles are not allowed (except as necessary for farming, etc.) The existing Mississippi River Trail extends the full length of the river, but lies mostly on public roads. The Big River Parkway is a planned trail extending from New Orleans, LA to St. Louis, MO on the levees. The Harahan Bridge over the Mississippi River will link Memphis, TN to this trail. This initiative will provide a unique opportunity for long distance riders. Shorter trails in and around towns and linking to this longer trail will still be needed. The Old Vicksburg Bridge is used for bicycling and pedestrian events and could become a permanent bicycling asset.

Lead Organization and Partners: The Big River Strategic Initiative is leading the development of the Big River Parkway. Any trail on the levee will require approval of the local levee district and a permit from USACE. USACE has some authority to add recreational features to flood risk management and ecosystem restoration projects. These opportunities may be limited, but should be explored with the non-Federal sponsors of the projects. Many local communities are developing bicycling lanes on existing roads and developing new bicycle/pedestrian trails.

Needs Addressed: This recommendation directly addresses needs for more Bicycle Trails and would provide opportunities to meet the needs for Interpretation.

Cost: Bicycle trails and amenities are highly variable. Urban trails can cost around $1,000,000 per mile including land acquisition, earth moving and paving. Creating the bicycling path on the Harahan Bridge may cost over $30,000,000.

Value: Americans spend more money every year on bicycling gear and trips ($81 billion) than they do on airplane tickets and fees ($51 billion) (OIA 2012). Bike trails and lanes in major metropolitan areas are expanding. As biking is becoming more popular, the demand for linking existing trails and creating longer routes is growing. Bike trails on levees and converted railroad lines would likely provide a positive economic return on the investment. The expansion of levee trails in Louisiana, the Big River Parkway from New Orleans to St. Louis, and the completion of the Harahan Bridge project at Memphis will spur more opportunities for bicycling in the region.

Riverfront Parks

Recommendation RP 3. Riverfront Parks – Develop riverfront parks for the use of local communities.

Lead Organization and Partners: NPS can help local communities plan these types of amenities and Parkway grants may be available to help cities pay for them. USACE Planning Assistance to States Program may also be able to help plan for these facilities.

Needs Addressed: This recommendation directly addresses needs for Riverfront Parks and would provide opportunities to meet the needs for Interpretation.

Cost: Varies based on site, size, and amenities.

Value: Local residents would appreciate these small gathering spots and they would provide excellent venues to teach people about the river. Informational signs could offer historical information as well as information about navigation and flood risk management on the river.

Riverboat Landings

Recommendation RP 4. Riverboat Landings – Develop more and better riverboat landings along the Lower River to provide reliable and accessible opportunities for riverboat passengers to visit and enjoy cities and towns all along the river.

Lead Organization and Partners: Local communities would lead these efforts and the NPS RCTA program and the USACE Planning Assistance to States Program may be able to help in planning for these facilities.

Needs Addressed: This recommendation directly addresses needs for Riverboat Landings and would provide opportunities to meet the needs for Interpretation.

Cost: Varies based on site, size, and amenities.

Value: Better facilities for riverboats would provide more consistent access and allow passengers of varying physical abilities to disembark. As the number of riverboats increases, there will be more opportunities for small towns to host passengers for day excursions. This would have an economic benefit. These landings can incorporate restaurants and interpretive facilities and become community assets beyond being riverboat docks.

Marketing

Recommendation RP 5. Marketing

> **Recommendation RP 5a.** National Geographic Geotourism Destination – Continue developing the Mississippi River as a Geotourism Destination which will include gathering and publicizing information on lodging, restaurants, amenities, museums, festivals, events, tours, culture, ecology and other features.
>
> *Lead Organization and Partners:* MRCC and Big River Strategic Initiative are working with National Geographic and gathering a group of other partners to support this initiative.
>
> *Needs Addressed:* This recommendation directly addresses the need for Marketing and will be valuable in addressing the needs for Lodging and Dining, Outfitters and Guides, Interpretation and Safety.
>
> *Cost:* $1,000,000
>
> *Value:* The National Geographic Society Geotourism Destination project would provide a one stop source to highlight all of the cultural, historical, natural and musical features of the Mississippi River and link potential travelers with lodging, dining and other services.
>
> **Recommendation RP 5b.** Great River Road – Pursue a National Parkway grant to develop a GPS feature for National Scenic Byways.

Lead Organization and Partners: The MRPC should work with a coalition of parkway commissions to get scenic byways included on GPS navigation systems.

Needs Addressed: This recommendation directly addresses the need for Marketing and will be valuable in addressing the needs for Lodging and Dining, Outfitters and Guides, Interpretation and Safety.

Cost: $1,000,000

Value: GPS navigation units are becoming standard for most travelers who depend on them to find hotels, restaurants, and other attractions. Scenic Byways are not programmed into GPS systems. The Great River Road does not follow a single highway route, and turn by turn directions are not included in the brochures. The route can be difficult to follow if the road signs are missing or not visible.

Lodging and Dining

Recommendation RP 6. Lodging & Dining **-** Develop more lodging and dining options on the LMR. Mobile food trucks at popular sites could meet some of the demand for dining on the LMR during peak usage, e.g. along the Big River Parkway on weekends. Most lodging would need to be developed outside of the batture, but there is some demand for camping along the river which could be met on State lands.

Lead Organization and Partners: Commercial interests should develop more lodging and dining options on the LMR. Local governments may have a limited role in permitting these services.

Needs Addressed: This recommendation directly addresses the need for more Lodging and Dining options.

Cost: Varies based on site, size, and amenities.

Value: Lodging and dining would enhance the recreational and tourism value of existing sites and encourage more visits to the area.

Outfitters and Guides

Recommendation RP 7. Outfitter and Guide **-** Establish more outfitter & guide services on the LMR.

Lead Organization and Partners: These will be mostly commercial enterprises, but non-governmental organizations like the National Audubon Society do sometimes offer guided field trips to view birds and other wildlife.

Needs Addressed: This recommendation directly addresses the need for more Outfitters and Guides and would improve Safety.

Cost: Varies based on services offered and geographic operating area.

Value: Outfitters and guides are needed to get visitors in the region to spend time on or near the Mississippi River. Many travelers may be interested in spending a day biking, fishing or

canoeing in the area, but will not want to bring the equipment with them. Travelers and local residents may lack the required skills to safely experience the river on their own.

Table 1. Summary of Conclusions

Data Science and Communications Program				
Recommendation		**Lead Organization**	**Cost**	**Value**
DISC 1	Science Technology Information Center	USGS	$2 million/year	Promote interagency cooperation, encourage research, foster public interest, and support other recommendations.
DISC 2	Sediment Study	USACE	$4 million/year	Support management plans, better manage dredging and coastal restoration.
DISC 3	Water Quality Monitoring Program	USGS & EPA	$2 million/ year	Provide clean water for people, industry, and habitat.
DISC 4	Tributary Watershed Studies	USACE	9 @ $1-$5 million each	Develop plans to manage tributaries for habitat, water quality, sediment, water supply, navigation and recreation.
DISC 5	Ecological Inventory	USACE & USFWS	$1.7 million	Provide information to support restoration.
Habitat Restoration and Management Program				
Recommendation		**Lead Organization**	**Cost**	**Value**
HRMP 1	Conservation Reach Studies	USACE	8 @ $3 million each	Restore aquatic (side channel, oxbow, main channel, islands, and sandbars) and terrestrial (wetlands, bottomland hardwoods, and floodplain) habitats for native species and especially federally listed species.
HRMP 2	Aquatic Habitat Restoration Studies	USACE & USFWS	125 @ $200,000 to $ 15 million (maximum)	Restore individual sites for native species.
HRMP 3	Terrestrial Habitat Program	USDA & LMVJV	$18,000,000	Restore floodplain habitat.
HRMP 4	Invasive Species Program	MICRA & ANSTF	Part of larger effort	Promote and protect native species.
Recreation Program				
Recommendation		**Lead Organization**	**Cost**	**Value**
RP 1	Boat Ramps	LMRCC and others	$50,000 - $750,000 each	Increase safety and meet recreation demand.
RP 2	Bicycle Trails	NGOs	variable	Increase safety and meet recreation demand.
RP 3	Riverfront Parks	Local Communities	variable	Promote community cohesiveness and meet demand.
RP 4	Riverboat Landings	Local Communities	variable	Provide safe, accessible opportunities and support local economic development.
RP 5	Marketing	NPS, MRPC, NGOs	$2 million	Promote river use and encourage economic development.
RP 6	Lodging and Dining	Private Enterprise	variable	Meet demand and support economic development.
RP 7	Outfitters and Guides	Private Enterprise	variable	Increase safety, meet demand and support economic development.

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APPENDIX A

Proposed Watershed Studies

Recommendation DISC 4

Bayou de Chien - Mayfield	A – 3
Obion	A – 5
Forked Deer	A – 7
Hatchie	A – 9
Bayou Pierre	A – 11
Big Black	A – 13
St. Francis	A – 15
Arkansas River	A – 17
Ouachita River	A – 19

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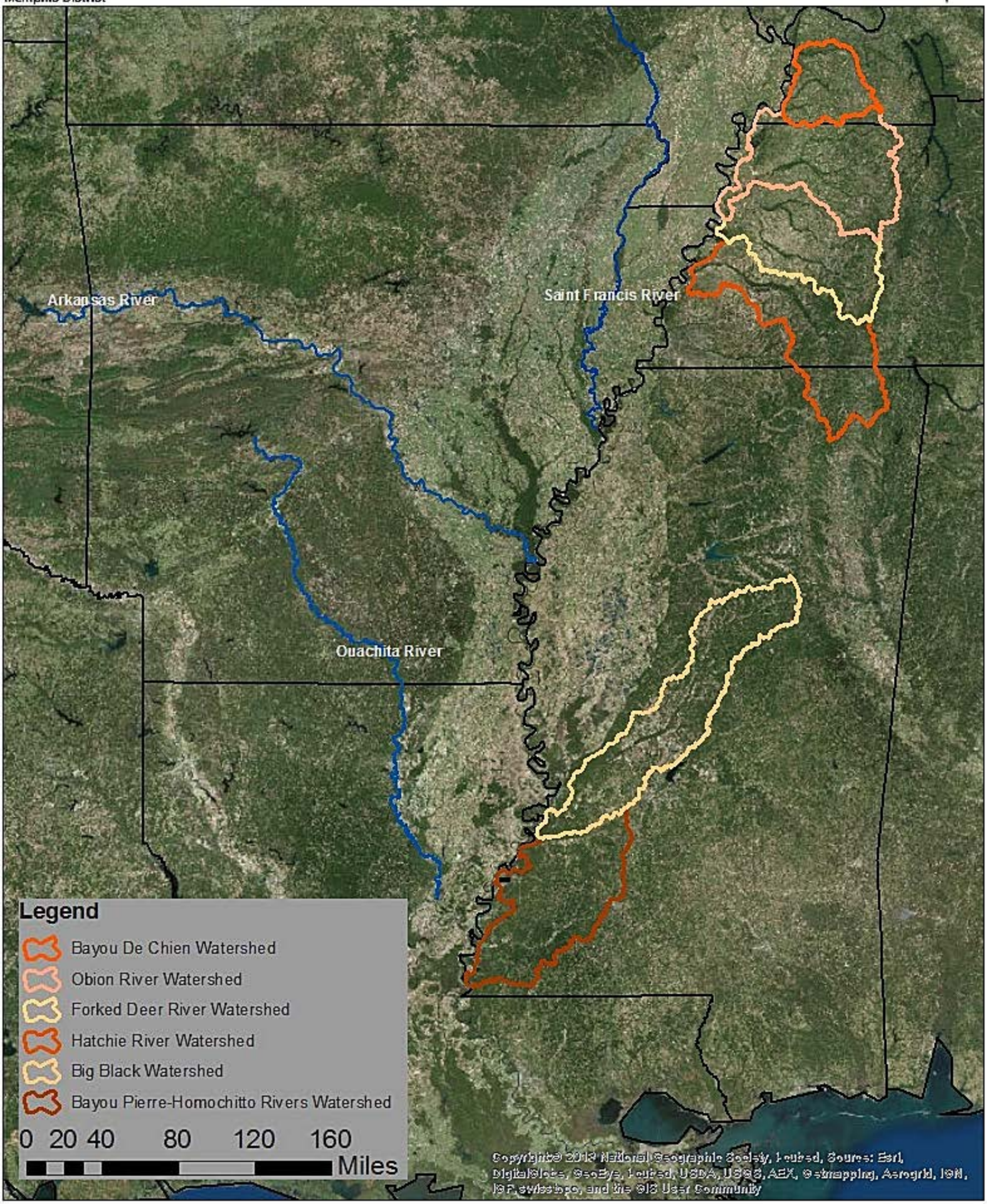
Tributary Watershed Studies



Watershed Name: Bayou de Chien-Mayfield

Watershed Size: 970 sq. mi.

Location: Bayou de Chien and Mayfield Creek arise in Graves County, KY and flow generally westward to the Mississippi River at Hickman, KY. Bayou de Chien flows into the Mississippi River at RM 922 forming Elvis Stahr (Hickman) Harbor. Mayfield Creek enters the river at RM 950.

Special Status Species: Relict darter (*Etheostoma chienense*), Indiana bat (*Myotis soldalis*)

General Description: The terrain along the upper portion of Bayou de Chien is rugged with narrow valleys that rise 50-100 feet along steep slopes to narrow ridges. Downstream of the Purchase Parkway, the valley along the main stem and major tributaries becomes quite wide. However terrain along smaller tributaries remains rugged with steep slopes rising in excess of 100 feet to narrow ridges. In the lower portion of the watershed, the slopes become less severe with elevation gains generally less than 50 feet. The north side of the watershed below Mud Creek is part of the Mississippi River floodplain where land is gently rolling with little elevation variance.

Land Use: The watershed is predominately agricultural. Forested areas are confined to wetlands and on the steeper slopes in the upper portion of the watershed. About 1200 acres of the Obion Creek Wildlife Management Area are located in the lower portion of the watershed. Residential, commercial, and industrial areas are located in and around Hickman. Residential areas are also located near Cayce, Crutchfield, and Water Valley.

Problems & Opportunities: Much of Bayou de Chien and its tributaries upstream of Highway 239 is an Outstanding Resource Water due to the presence of the relict darter. Much of the valley along the main stem is wetland.

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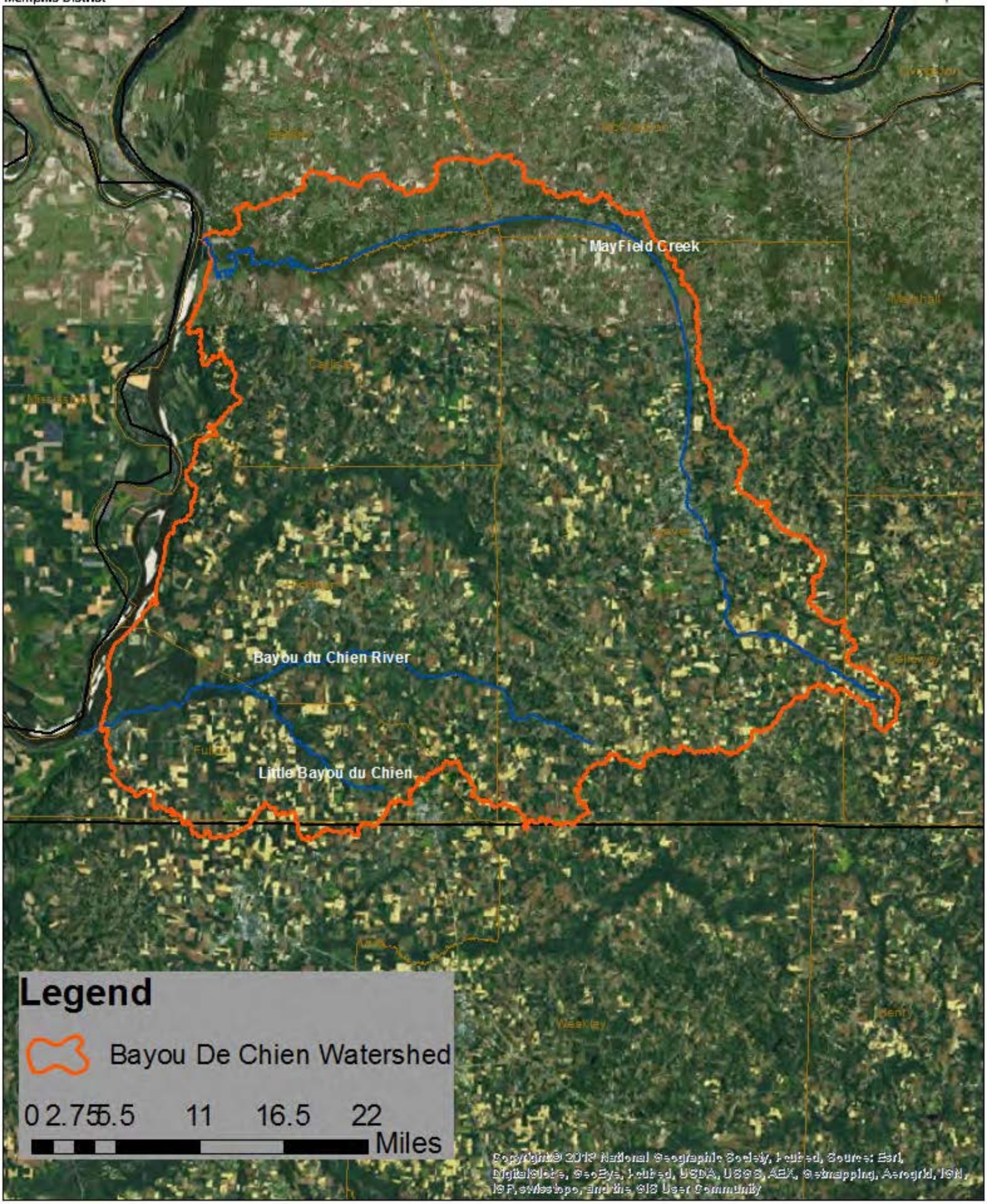
Bayou du Chien Watershed



Watershed Name: Obion

Watershed Size: (2473 sq. mi.)

Location: The Obion River is located in northwest Tennessee and includes parts of Carroll, Henderson, Dyer, Gibson, Henry, Lake, Lauderdale, Obion, and Weakley counties. It enters the Mississippi River at RM 819

Special Status Species: Pallid sturgeon (*Scaphirhynchus albus*), alligator snapping turtle (*Macroclemys temminckii*), alligator gar (*Lepisosteus spatula*), Indiana bat (*Myotis soldalis*), northern madtom (*Noturus stigmosus*), and the firebelly darter (*Etheostoma pyrrhogaster*).

General Description: The Obion River system is the primary surface water drainage system of northwest Tennessee and is comprised of four major forks, the North Fork, Middle Fork, South Fork and Rutherford Fork that each flow as separate streams for the majority of their lengths. The confluences of these forks are only a few miles above the mouth of the Obion's discharge into the Mississippi River.

Land Use: Lake Isom and Reelfoot Lake National Wildlife Refuges lie within the watershed as well as smaller wildlife management areas and refuges. The Obion River is separated into three watersheds: North Fork of the Obion, South Fork of the Obion and the Rutherford Fork of the Obion. Gooch Wildlife Management Area also lies in the watershed.

Problems & Opportunities: The Obion River, like many others in west Tennessee, has been heavily modified to alleviate the risk of flooding for residents and agriculture. Row-crop production and pasture land, dominate land use in the watershed. Best Management Practices, improved zoning guidelines, building codes, streamside buffer zones and greenways, and general landowner education could reduce sedimentation. Other management measures may include re-establishing bank vegetation to stabilize banks, and restoring wetlands and meanders to reduce water velocity and scouring.

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Obion Watershed

Watershed Name: Forked Deer

Watershed Size – (2086 sq. mi.)

Location: The Forked Deer River watershed covers several counties in West Tennessee. It originally entered the Mississippi River near RM 803, but the lower end of the river was rerouted into the Obion which enters the river at RM 819.

Special Status Species: Firebelly darter (*Etheostoma pyrrhogaster*), barking treefrog (*Hyla gratiosa*), Indiana bat (*Myotis soldalis*), and the Hatchie burrowing crayfish (*Fallicambarus hortoni*), as well as heron rookeries

General Description: The Forked Deer has three major branches, the North fork, Middle Fork and South Fork. Most of the system has been channelized. There are numerous small dams for flood detention and sediment storage.

Land Use: Land use in the Forked Deer River Watershed is predominately row crop agriculture and pasture. The Tigrett Wildlife Management Areas is over 7,500 acres and provides habitat for waterfowl, wading birds, bald eagle and Mississippi kite.

Problems & Opportunities: Excess sediment within the watershed has caused valley plugs to form within channelized reaches of the river, and they will likely continue to form as degradation of upstream reaches of the Forked Deer and its tributaries continues and the watershed struggles to reach equilibrium. Valley plugs can force the river into old meanders and cause higher flood elevations or ponding within wooded areas leading to tree mortality. Forested tracts of the Forked Deer River appear to have shifted from dominantly mixed oak, sweetgum, and bald cypress to a more disturbance tolerant mix of red maple, black willow, and river birch. Conditions within the watershed are not likely to substantially improve without major watershed-scale interventions such as meander restoration, restoration of hydrology, and bottomland hardwood restoration as well as sediment load reductions.

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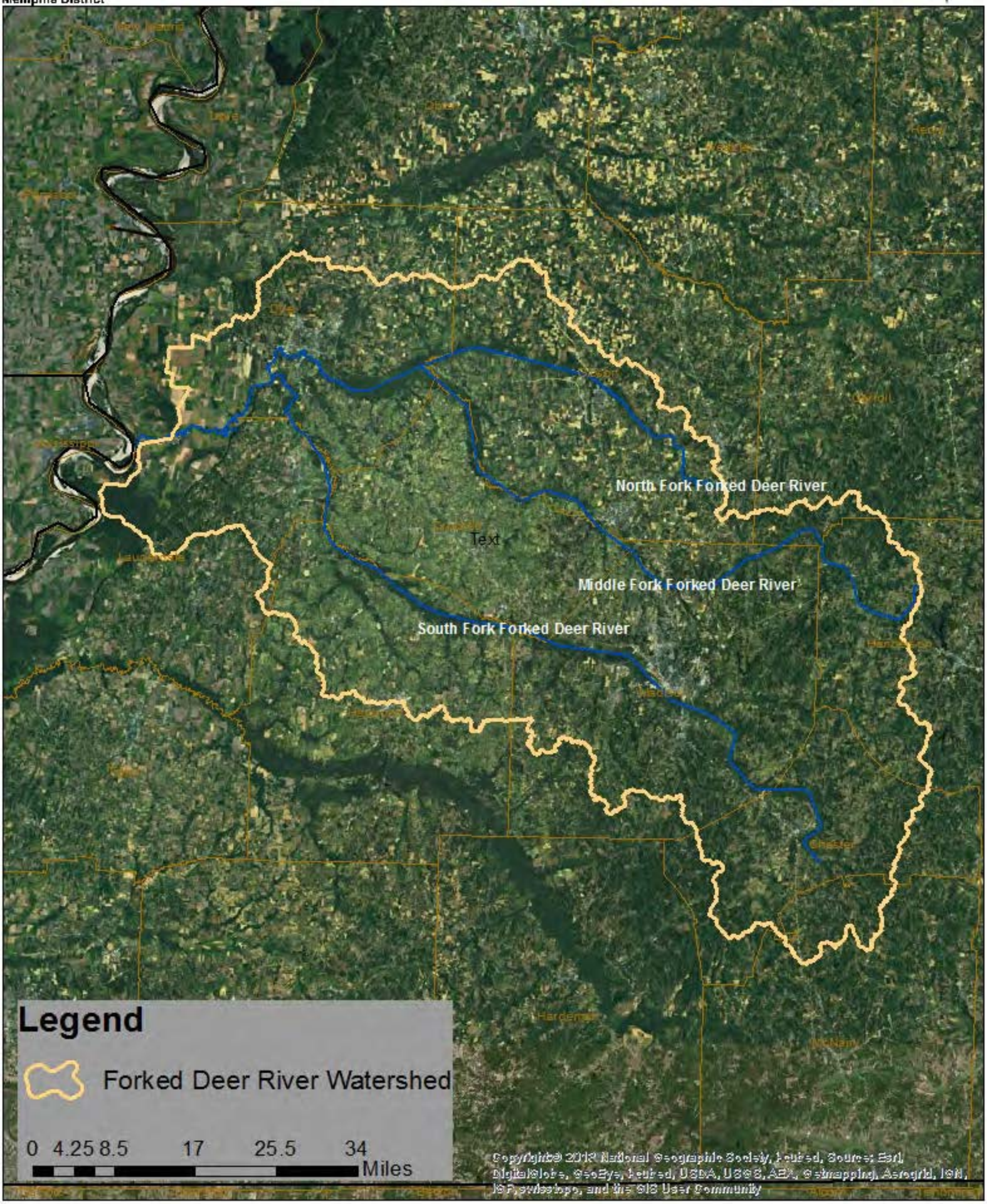
Forked Deer Watershed



Watershed Name: Hatchie

Watershed Size: (2610 sq. mi.)

Location: The Hatchie River is located in west Tennessee and north Mississippi and includes parts of Hardeman, McNairy, Haywood, Madison, Tipton, and Lauderdale Counties in TN and Carroll, Henderson, Dyer, Gibson, Henry, Lake, Lauderdale, Obion, and Weakley counties. It enters the Mississippi River at RM 773

Special Status Species: Indiana bat (*Myotis soldalis*), naked sand darter (*Ammocrypta beanii*), rabbitsfoot mussel (*Quadrula cylindrica*), bald eagle (*Haliaeetus leucocephalus*), Swainson's, prairie and cerulean warblers.

General Description: The Hatchie River is the only undammed and unchannelized tributary to the LMR. Most of the Hatchie's 36 tributaries have been channelized or altered, and they are carrying heavy sediment loads into the Hatchie. The increased sediment from the tributaries threatens to create valley plugs in the Hatchie. The Hatchie River contains the largest forested floodplain in Tennessee.

Land Use: The area includes the Hatchie National Wildlife Refuge (11,500 + acres), Lower Hatchie River NWR (9,500 acres), the Chickasaw NWR (25,000 ac), Chickasaw State Forest (12,500 ac), Big Hill Pond State Park (5,000 ac) and the Fort Pillow State Historic Park, the site of an infamous Civil War battle. USDA has acquired Wetland Reserve Program Easements throughout the watershed.

Problems & Opportunities: The natural flood processes that drive the ecosystem are intact, sustaining the river and wetland habitats that support a rich ecological diversity. These habitats support more than 100 species of fish and 35 species of mussels. With 11 species of catfish, the Hatchie probably contains more species of catfish than any other river in North America.

USGS is actively studying the Upper Mississippi Embayment (groundwater), and the Hatchie watershed overlies part of the recharge zone. This aquifer supplies 17% of all water withdrawn from aquifers in the U.S. and is one of the most valuable natural resources in the region.

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Hatchie Watershed

Watershed Name: Bayou Pierre

Watershed Size: (1070 sq. mi)

Location: Bayou Pierre originates northwest of Brookhaven and along with the Homochitto and Buffalo Rivers drains much of Hinds, Lincoln, Franklin, Copiah and Claiborne Counties in MS. It enters the Mississippi River at River Mile 395. The Homochitto and Buffalo Rivers would be included in this study.

Special Status Species: Bayou darter (*Etheostoma rubrum*)

General Description: Bayou Pierre is experiencing an alarming land loss rate due to bank caving and head-cutting, directly impacting the endangered bayou darter and its habitat. Bayou Pierre is the only remaining habitat of the bayou darter and further degradation could jeopardize the continuing existence of the species. In addition, effluent runoff from poultry industry could lead to stream contamination and fish kills. The watershed investigation could lead to new alternatives to combat these problems and directly benefit the habitat of the bayou darter. Ross et al. (2001) noted extensive erosion throughout the system. The lower reaches of the watershed are recovering, but headcutting is ongoing in the upper reaches. Headcutting is a common problem in LMR tributaries (Shankman 1996). The Mississippi River has degraded in some reaches and caused headcuts to progress up the tributaries. Soils in the region are highly erodible and the rivers are not able to re-stabilize without intervention. Despite these conditions, the bayou darter population remains stable (Ross et al. 2001).

Land Use: Timberlands dominate the watershed, but, livestock grazing and row crop agriculture are also common. The 191,000- acre Homochitto National Forest lies in the watershed.

Problems & Opportunities: The Bayou Pierre Watershed Enhancement Group includes a group of landowners, agencies, and organizations striving to improve the quality of the water, land, and wildlife within the watershed.

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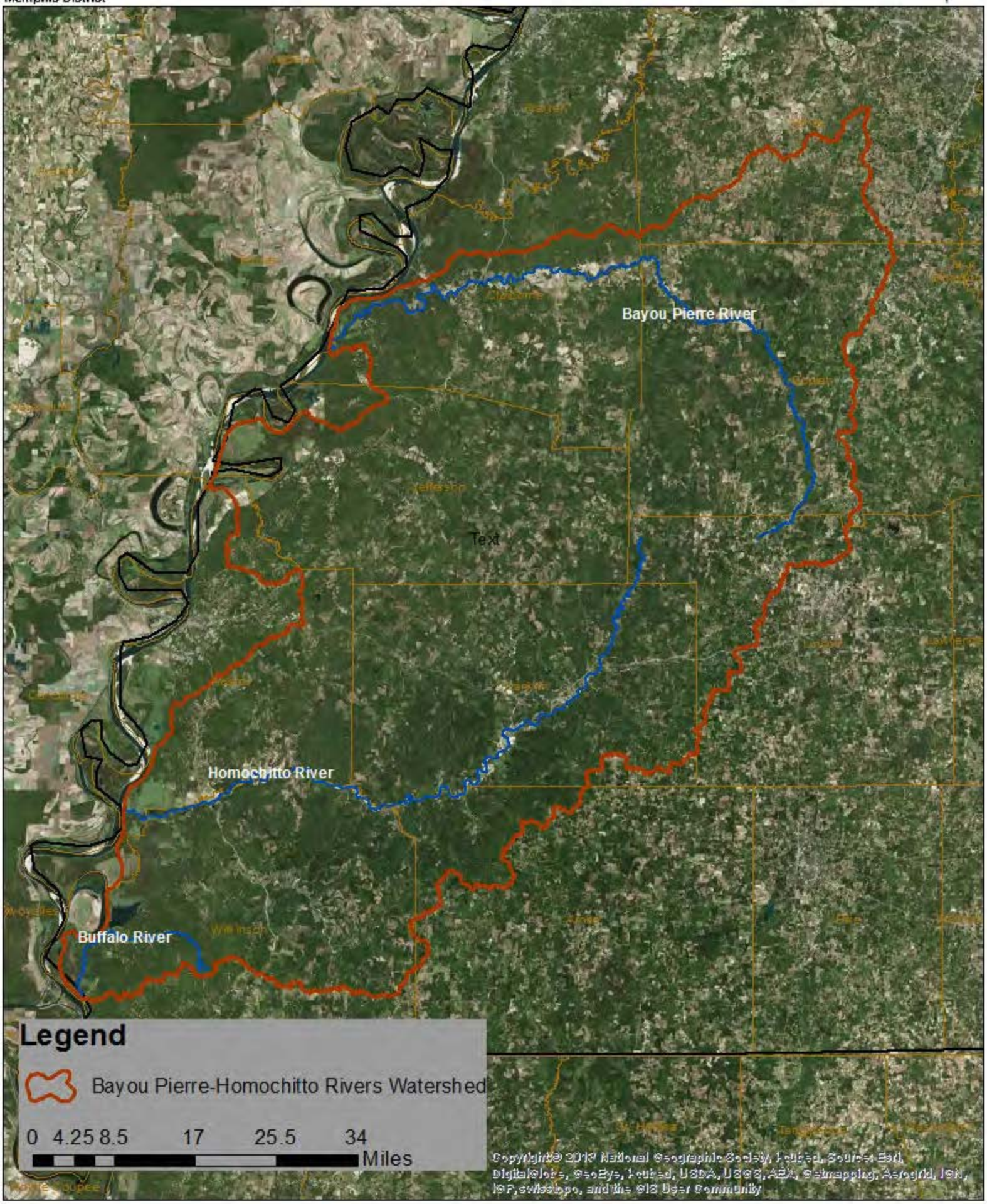
Bayou Pierre-Homochitto Watershed



Watershed Name: Big Black

Watershed Size- (3384 sq. mi)

Location: The Big Black River originates in Webster County near Eupora, MS and flows about 300 miles towards the southwest overlying Choctaw, Montgomery, Carroll, Holmes, Attala, Yazoo, Madison, Claiborne, Hinds, and Warren Counties, MS. It enters the Mississippi River at River Mile 409.

Special Status Species:

General Description: The estimated population within the Big Black River watershed exceeds 176,000, with residents primarily located around Jackson and surrounding communities. The Big Black River watershed includes 3 of the fastest developing residential and business areas in the state. The basin is also known for producing large whitetail deer.

Land Use: According to the U.S. Geological Survey, land cover in the watershed is approximately 56% forested and 39% agriculture, and the remaining areas are developed. Agricultural runoff results in large amounts of suspended sediments and turbid conditions, primarily in the northern part of the basin. Although most of the basin streams are turbid with low current velocity, other basin streams have swift current, sandy substrate, and relatively clear water. The site of the Civil War Battle of Big Black River Bridge lies in the watershed.

Problems & Opportunities: The Mississippi Department of Environmental Quality is currently investigating non-point source pollution control measures in the Big Black River Basin because water quality is significantly influenced in certain areas of the watershed by diverse land based urban development and stormwater runoff, agricultural activities, and sedimentation.

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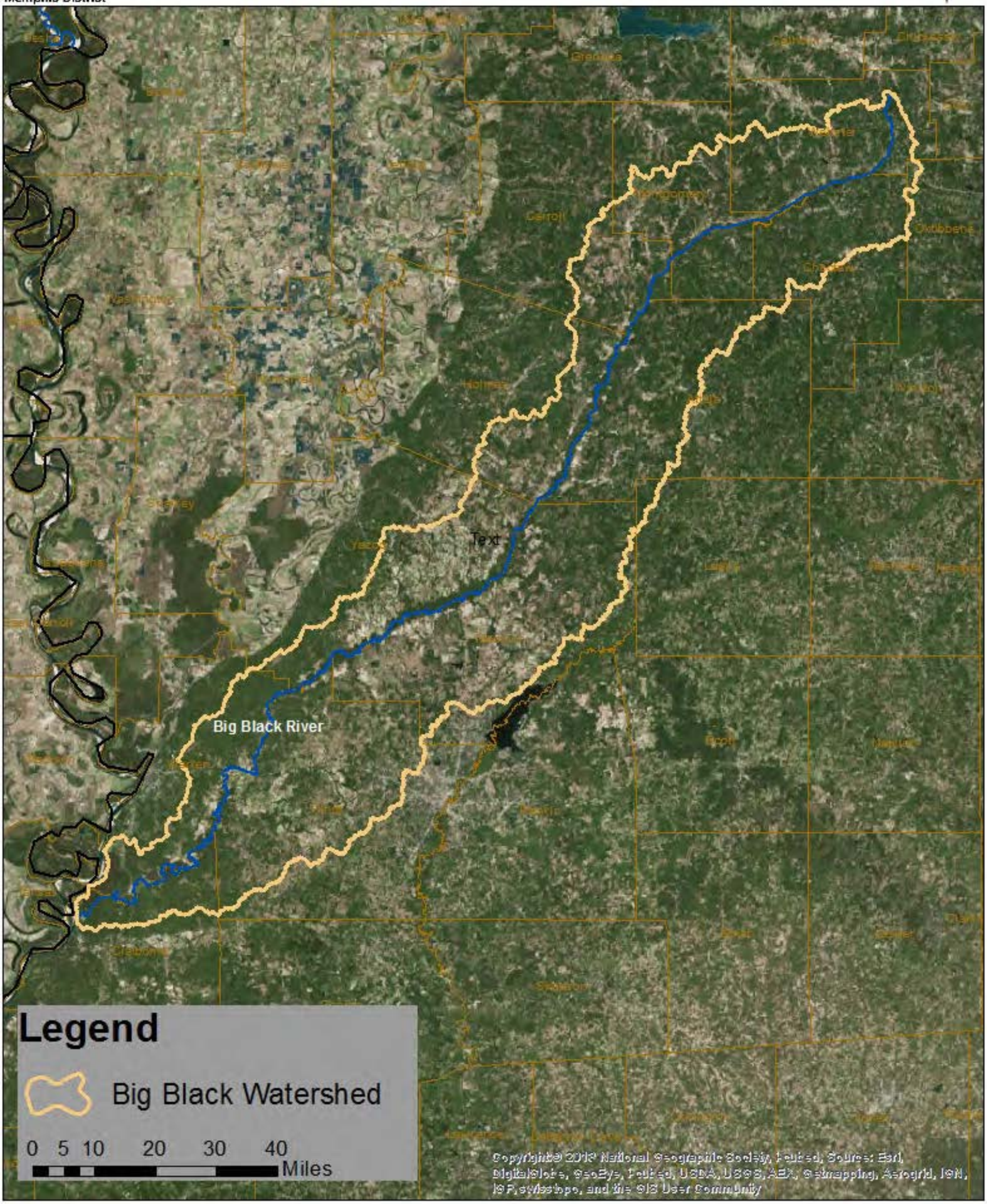
Big Black Watershed



River Name: St. Francis

River Location: the St. Francis River heads in Missouri, flows over 400 miles south through Arkansas, and enters the Mississippi River at RM 672.

Specific Proposal: Conduct a study of the water resources of the St. Francis River Basin to assess the opportunities for water reallocation among the various channels, ecosystem restoration, agricultural water supply, and recreation projects compatible with the existing flood risk management system. Most of the watershed now drains into the Mississippi River through the Huxtable Pumping Station near Marianna, AR.

Lead Organization and Partners*:* USACE would lead the study with participation from USDA, St. Francis Levee and Drainage District, Arkansas state resource agencies, and others.

Needs Addressed: This recommendation directly addresses the need for better Tributary Management. This recommendation will be important in addressing needs for Water Quality, Sediment, and Floodplains and may provide opportunities to meet the need for more Bicycle Trails.

Cost: $3,000,000

Value: The St Francis River basin covers over 7500 square miles in Arkansas and Missouri. The watershed contains valuable agricultural land and is one of the premier rice growing regions in the world. The rivers and streams have been altered to facilitate drainage. Despite the stream alterations, the basin still supports a healthy assemblage of mussels and many thriving populations of the federally listed fat pocketbook mussel. The historic meandering channel carries little water now, but still has several large mussel beds.

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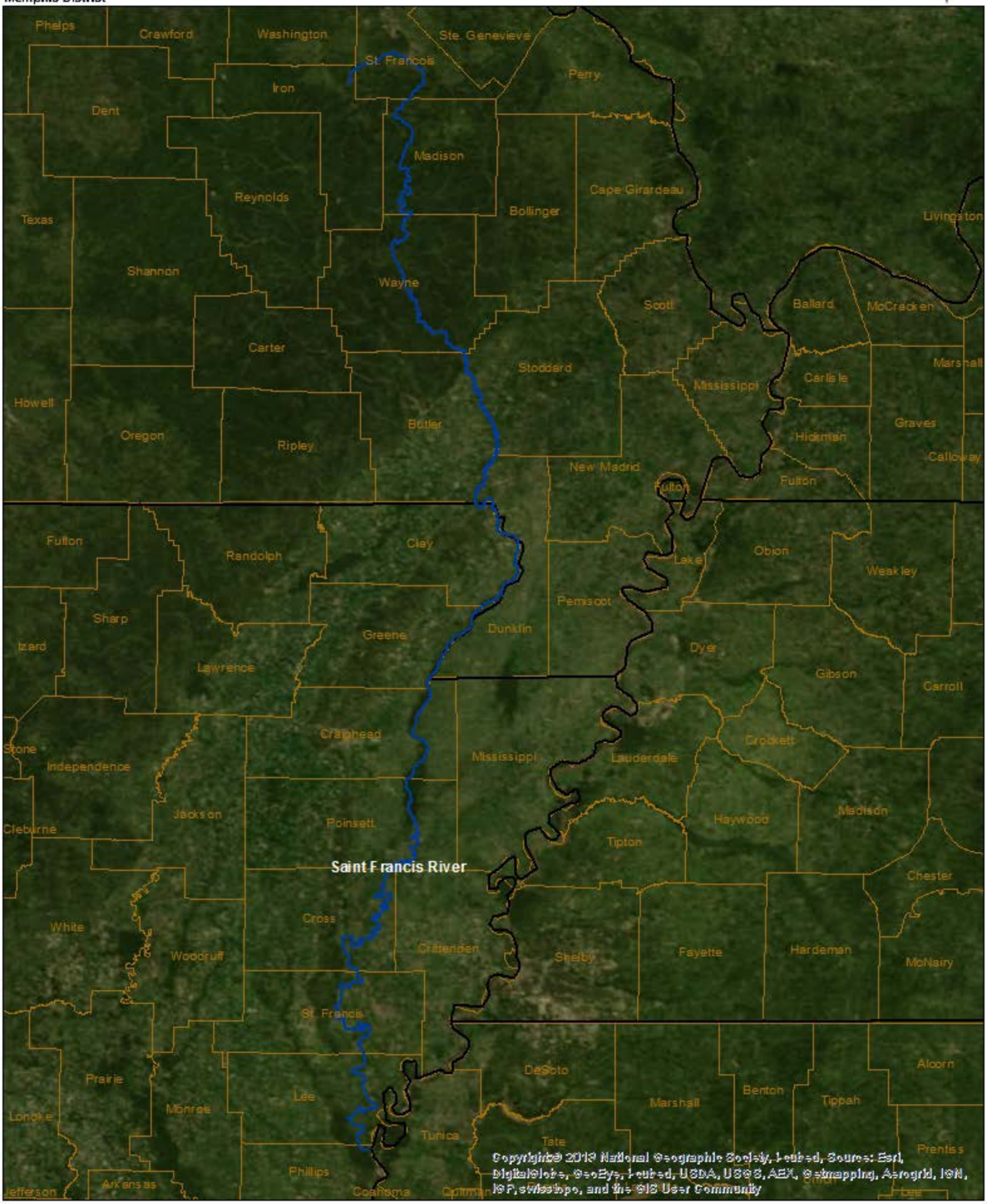
St. Francis River



River Name: Arkansas River

River Location: The Arkansas River heads at the Continental Divide in Colorado and flows over 1,400 miles southeast through Kansas, Oklahoma, and Arkansas and enters the Mississippi River at RM 580.

Specific Proposal: The Arkansas is the sixth longest river in the United States and the largest tributary of the Lower Mississippi River. It is important for habitat, recreation, navigation, and water supply. The upper end of the watershed includes several Bureau of Reclamation projects, and the middle and lower portions include large reservoirs for flood risk management and hydropower production and the McClellan-Kerr Arkansas River Navigation System. The recommended study would examine the immediate (or active) floodplain of the river and the existing water resources features and assess the need for projects to improve habitat, recreation, water supply, and other uses.

Lead Organization and Partners: USACE would lead the study with participation from state and federal agencies in Arkansas, Oklahoma, Kansas and Colorado.

Needs Addressed: This recommendation directly addresses the need for better Tributary Management. This recommendation will be important in addressing needs for Water Quality, Sediment, and Floodplains and may provide opportunities to meet the need for more Bicycle Trails.

Cost: This study would be expected to cost between $5,000,000 and $7,000,000.

Value: The Arkansas River is the largest tributary of the Lower Mississippi River. Five states: Arkansas, Oklahoma, Texas, Kansas, and Missouri are dependent on the McClellan-Kerr Arkansas River Navigation System (MKARNS). Arkansas is a Top Ten State for producing sorghum, soybeans, cotton, and livestock; and the number one producer of rice. These foodstuffs are transported on the MKARNS. The watershed contains two National Forests, multiple National Wildlife Refuges, and thousands of acres of wetlands and pristine bottomland hardwood forests. It provides habitat for several federally listed endangered species including interior least tern, pink mucket mussel, and fat pocketbook mussel, and wood stork.

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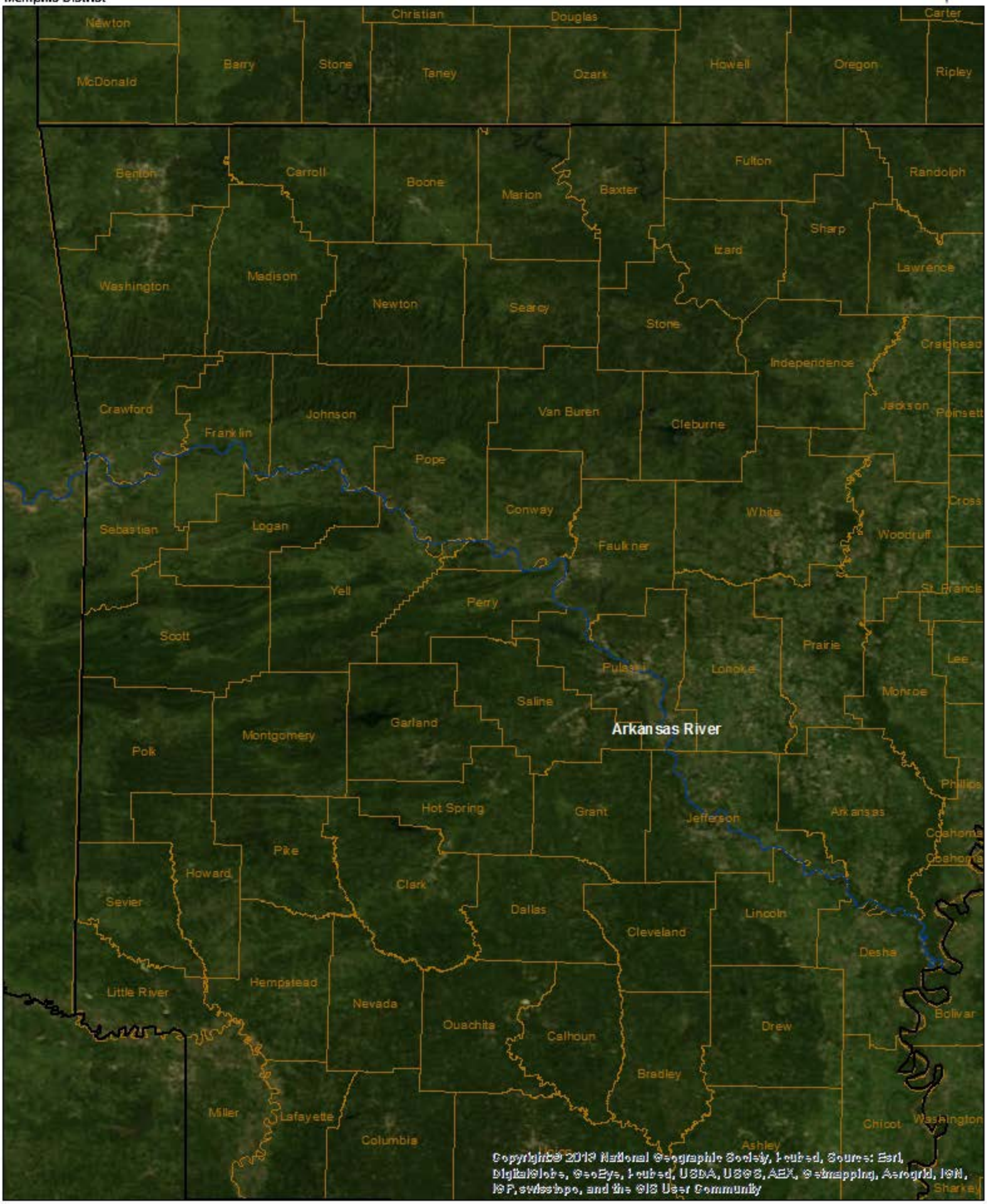
Arkansas River



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River Name: Ouachita River

River Location: The Ouachita River originates in Polk County, Arkansas, and flows 510 miles in a southerly direction to Jonesville, Louisiana, where it converges with the Tensas and Little Rivers to form the Black River. The Black River meets the Red River 41 miles south of Jonesville. About 28 miles below the mouth of Black River, the Red River comes to a junction with the head of the Atchafalaya River and the western end of the 7-mile-long Old River, which historically linked these rivers to the Mississippi River.

Specific Proposal: Ouachita River basin is one the most environmentally, economically and culturally diverse watersheds in the entire Mississippi River Watershed. It covers 19,000 square miles across south-central Arkansas and north-central Louisiana. Fifty-nine percent of the watershed is forested and twenty-nine percent is agricultural land. It contains one National Forest, three National Wildlife Refuges, twelve Arkansas Wildlife Management Areas and four Louisiana Wildlife Management Areas. Major cities include Hot Springs and Camden, Arkansas and Monroe, Louisiana. The Ouachita River basin contains a wide range of water resources infrastructure and provides a unique opportunity to demonstrate a watershed-based Integrated Water Resources Management (IWRM) budgeting approach consistent with the National Watershed Vision.

Lead Organization and Partners*:* USACE would lead the study with the Ouachita River Valley Association.

Needs Addressed: This recommendation directly addresses the need for better Tributary Management. This recommendation will be important in addressing needs for Water Quality, Sediment, and Floodplains and may provide opportunities to meet the need for more Bicycle Trails.

Cost: $3,000,000

Value: The study would develop a strategic plan for the Ouachita River Watershed to prioritize activities within the basin. Water resources problems include flooding of urban and rural properties. Bank caving along the river is endangering levees that provide urban and rural flood protection. During October 2009, high flows were threatening levees in several locations. Future bank caving could cause levee failures or significant damage to public infrastructures adjacent to or located on the banks. These damages could lead to significant flooding of area development and/or potential loss of life. Significant problems with navigation on the Ouachita River have been experienced in recent years because authorized cutoffs were never constructed and the existing radius of bendways above Monroe, Louisiana, is too small for tows to make the turns without "light loading" of barges.

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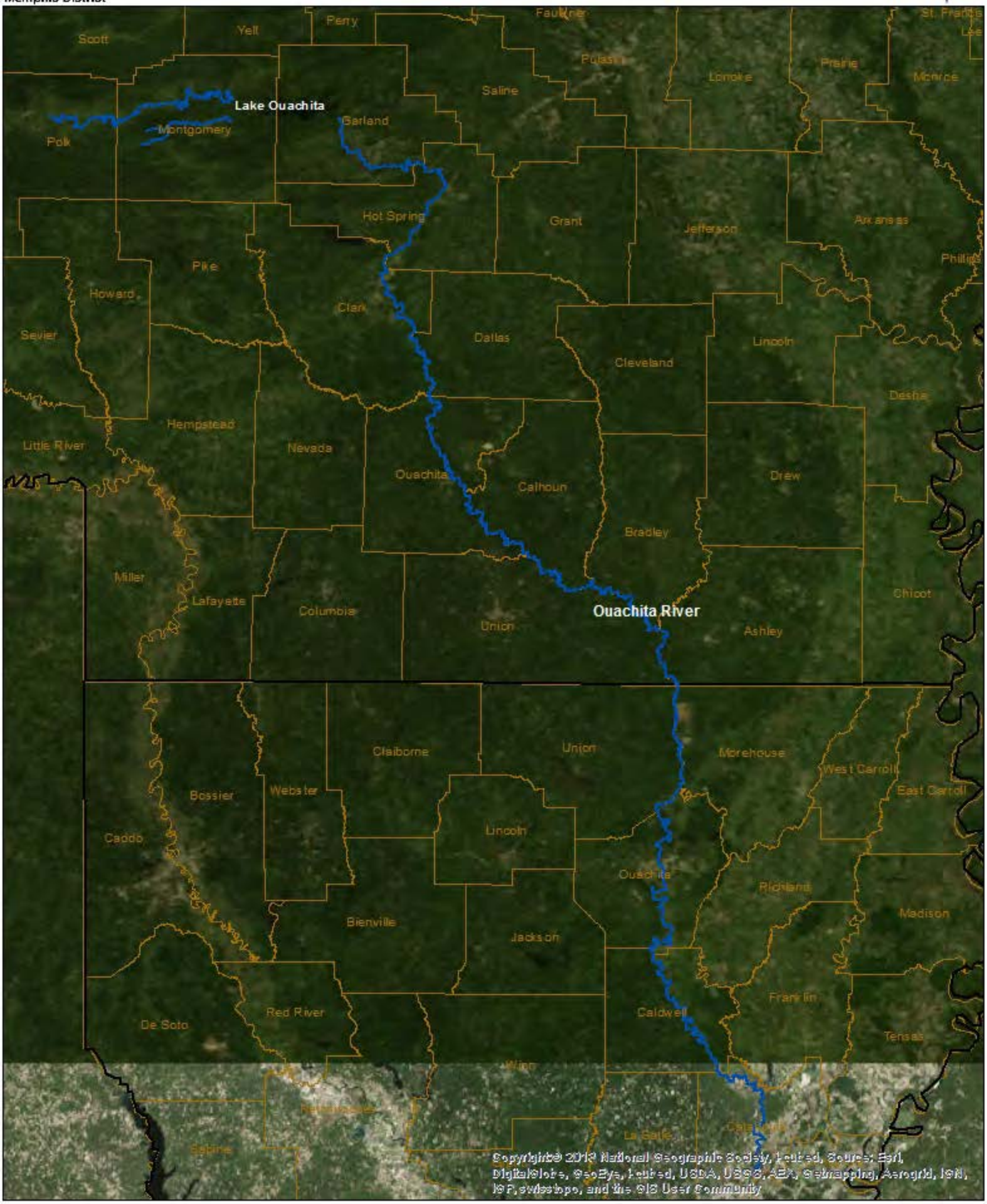
Ouachita River



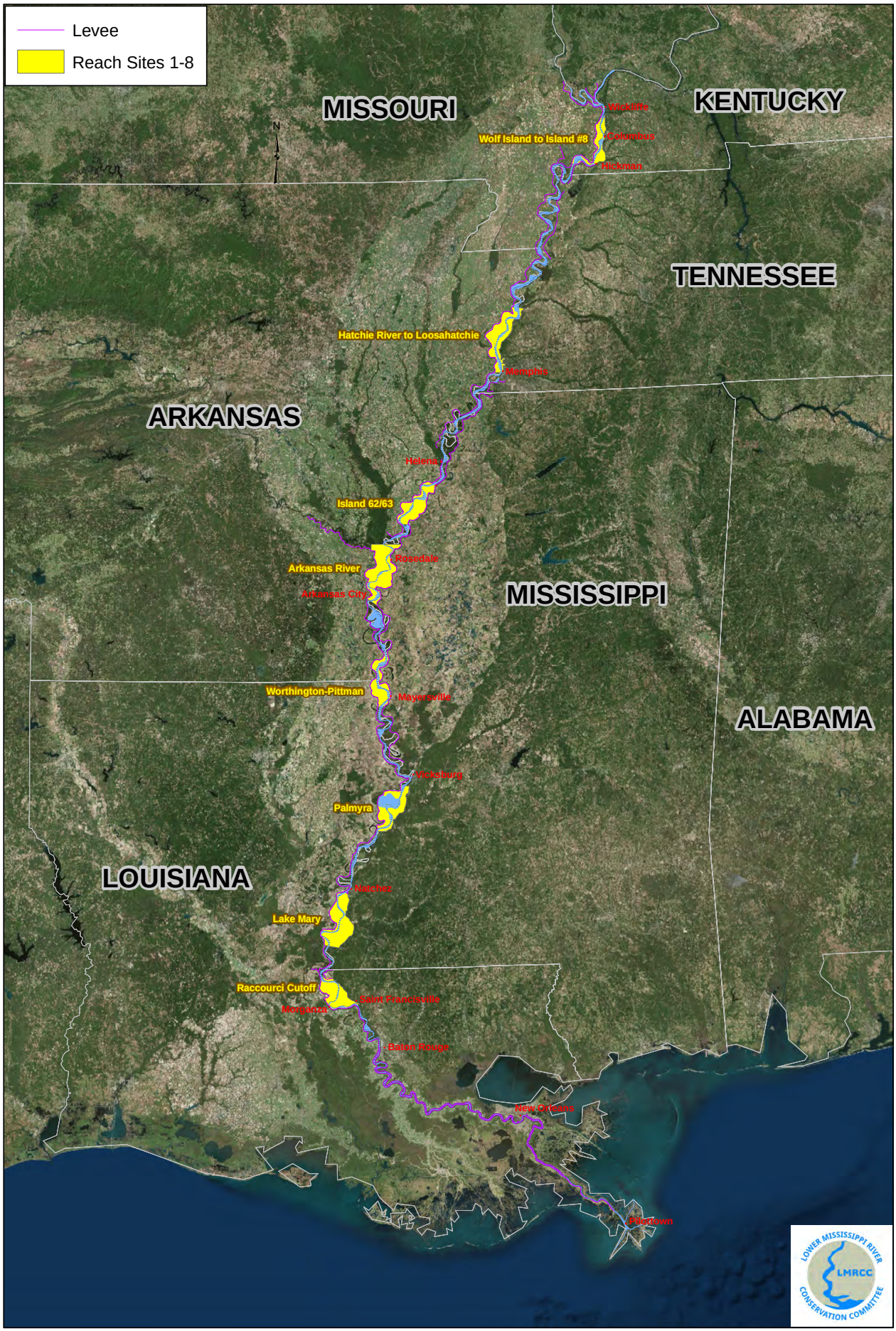
APPENDIX B

Conservation Reaches

Recommendation HRMP 1

Reach 1 Wolf Island to Island #8	B – 3
Reach 2 Hatchie River to Loosahatchie	B – 5
Reach 3 Island 62/63 Reach	B – 7
Reach 4 Arkansas River	B – 9
Reach 5 Worthington-Pittman	B – 11
Reach 6 Palmyra	B – 13
Reach 7 Lake Mary	B – 15
Reach 8 Raccourci Cutoff	B – 17

LMRRA Conservation Reach Study
Restoration Site Reaches 1-8



Prepared by LMRCC 06/Oct/2014

Reach #1: Wolf Island to Island #8

River Miles: RM 946 – 910 (36 miles)

Description: The upstream end of the reach is located eight miles below the confluence with the Ohio River and extends 36 miles to below the Bend of Island #8. Two large side channels (i.e., Wolf Island Chute and Bend of Island #8) highlight this reach, plus one tributary (i.e., Obion Creek in KY), several crossovers and one large river bend; numerous smaller secondary and tertiary channels, sloughs, and other backwaters, seven dikes fields (16 notched dikes), and 12 revetments. The distance between the levee on the west side and the bluff on the east varies 2-8 miles. Island #8 is about two miles wide.

T&E Species: Wolf Island Chute supports one of the highest concentrations of shovelnose sturgeon in the upper part of the Lower Mississippi River. Pallid sturgeon are frequently captured in this area as well. Island #8 also supports both shovelnose and pallid sturgeon, as does this entire reach. Six active interior least tern colonies have been observed in this reach. This reach is potential habitat for Indiana bat. Bald eagles frequently nest in and near this reach.

Public Access: Six boat ramps provide access to this reach, plus an additional boat ramp located about 5.5 miles upstream from the reach.

LMRCC Projects: 12 projects have been identified in this reach:

- Create, rehabilitate, and diversify secondary channels (6 projects)
- Enhance main channel habitat diversity (5 projects)
- Restore and diversify floodplain water bodies (1 project)

Project specifics noted on map:

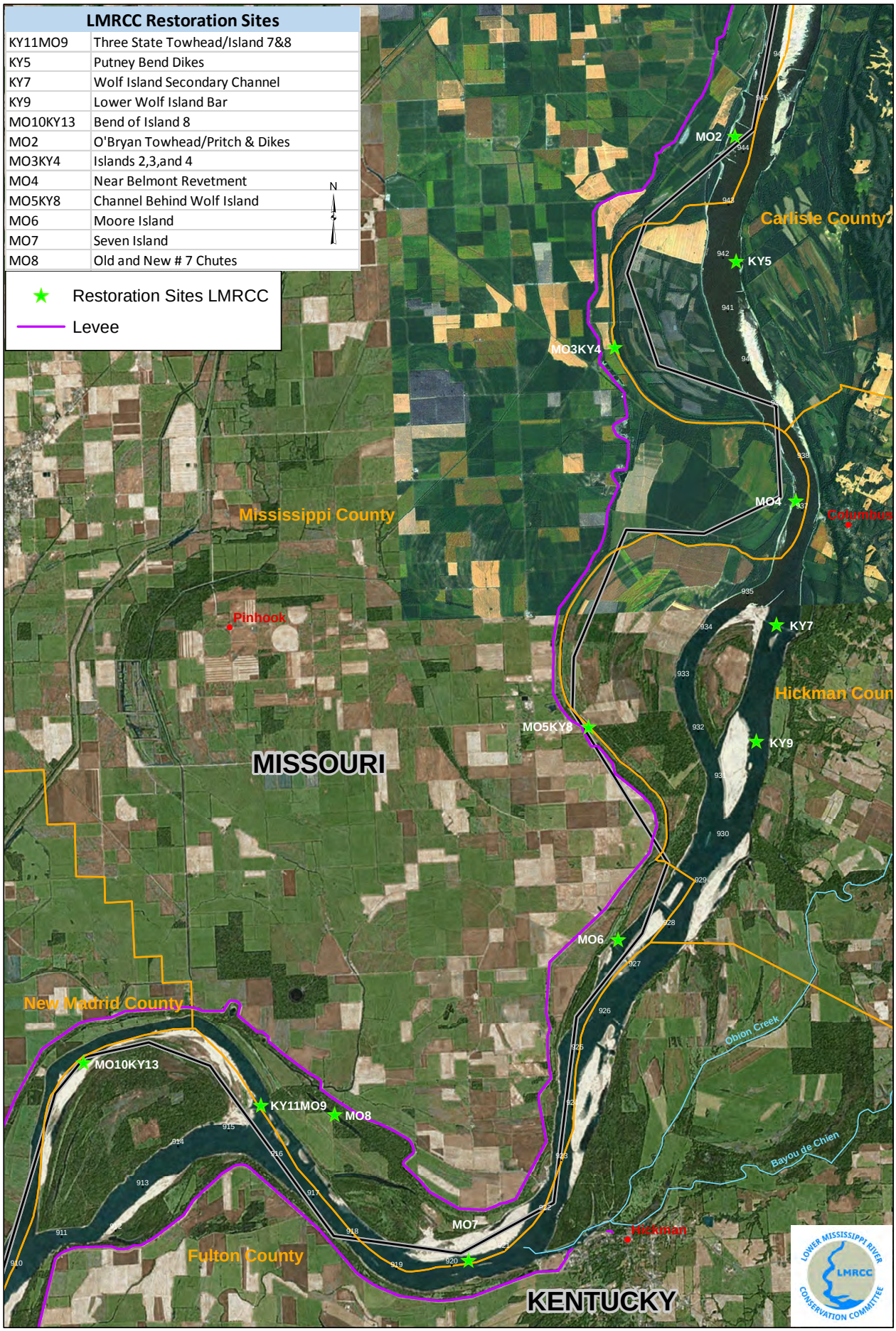
- KY5: Putney Bend Dikes - Enhance main channel habitat diversity
- MO10KY13: Bend of Island 8 - Create, rehabilitate, and diversify secondary channels
- MO3KY4: Islands 2,3,and 4 - Create, rehabilitate, and diversify secondary channels
- MO4: Near Belmont Revetment - Enhance main channel habitat diversity
- MO5KY8: Channel Behind Wolf Island - Create, rehabilitate, and diversify secondary channels
- MO7: Seven Island - Enhance main channel habitat diversity
- MO8: Old and New # 7 Chutes - Restore and diversify floodplain water bodies

Completed or Underway Projects:

- KY11MO9: Three State Towhead/Island 7&8 - Create, rehabilitate, and diversify secondary channels (completed)
- KY9: Lower Wolf Island Bar - Create, rehabilitate, and diversify secondary channels (completed)
- KY7: Wolf Island Secondary Channel - Create, rehabilitate, and diversify secondary channels (underway)
- MO2: O'Bryan Towhead/Pritch & Dikes - Enhance main channel habitat diversity (underway)
- MO6: Moore Island - Enhance main channel habitat diversity (completed)

LMRRA Conservation Reach Study
Wolf Island to Island #8 - River Mile 946 to 910

LMRCC Restoration Sites	
KY11MO9	Three State Towhead/Island 7&8
KY5	Putney Bend Dikes
KY7	Wolf Island Secondary Channel
KY9	Lower Wolf Island Bar
MO10KY13	Bend of Island 8
MO2	O'Bryan Towhead/Pritch & Dikes
MO3KY4	Islands 2,3,and 4
MO4	Near Belmont Revetment
MO5KY8	Channel Behind Wolf Island
MO6	Moore Island
MO7	Seven Island
MO8	Old and New # 7 Chutes



Prepared by LMRCC 06/Oct/2014

Reach #2: Hatchie River to Loosahatchie

River Miles: RM 775 – 736 (39 miles)

Description: This reach extends from just above the Hatchie Towhead dike field downstream to include Hopefield Dikes. Over 10 dike fields, numerous crossings and pools, side channels, old bendways, and wide overbank areas between west levee and east bluff (2-9 miles). In addition, there are three tributaries/river mouths in the reach (i.e., Hatchie, Loosahatchie, and Wolf Rivers). Habitat restoration efforts have been conducted on the Loosahatchie Bar (e.g., dike and closure notching), across the river from Memphis, with pre- and post-project surveys and biological assessments. Meeman Shelby State Park and Fort Pillow State Park both border this reach, and the Lower Hatchie National Wildlife Refuge and JM Tulley Wildlife Management area are adjacent to it.

T&E Species: Eight active interior least tern colonies and fat pocketbook mussel shells have been observed. The reach has good potential for pallid sturgeon and Indiana bat.

Public Access: There are boat ramps at Richardson Landing, Memphis Riverfront, and Meeman-Shelby State Park.

LMRCC Projects: 17 projects already identified in this reach and includes dike notching, tributary/mouth restoration, wetland complex restoration, and lake level stabilization.

- Create, rehabilitate, and diversify secondary channels (8 projects)
- Restore and diversify floodplain water bodies (2 projects)
- Augment aquatic connectivity with the floodplain (4 projects)
- Tributary enhancement (3 projects)

Project specifics noted on map:

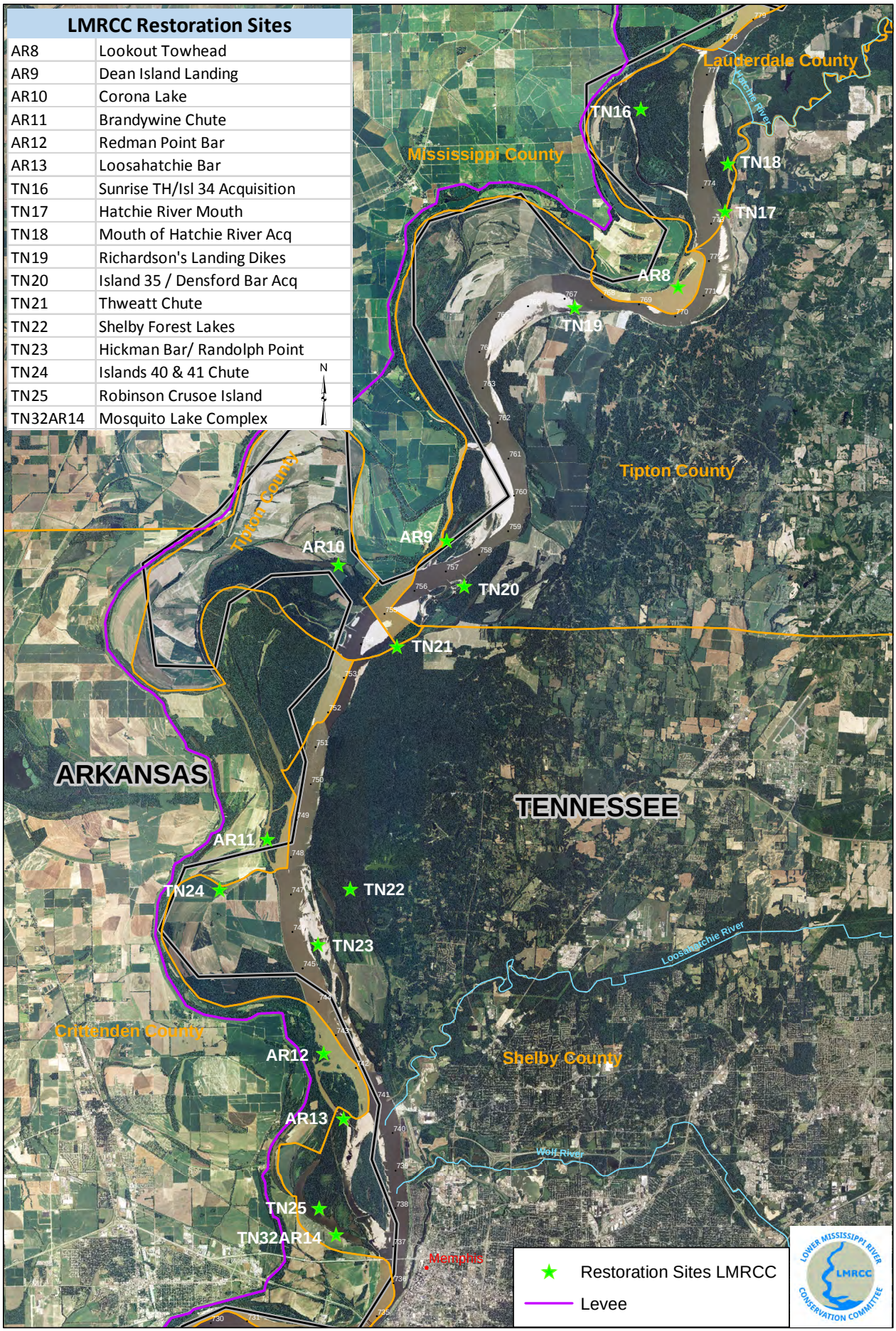
- AR11: Brandywine Chute - Create, rehabilitate, and diversify secondary channels
- AR9: Dean Island Landing - Restore and diversify floodplain water bodies
- TN16: Sunrise TH/Isl 34 Acquisition - Augment aquatic connectivity with the floodplain
- TN18: Mouth of Hatchie River Acquisition - Tributary enhancement
- TN20: Island 35 / Densford Bar Acquisition - Augment aquatic connectivity with the floodplain
- TN21: Thweatt Chute - Create, rehabilitate, and diversify secondary channels
- TN22: Shelby Forest Lakes - Augment aquatic connectivity with the floodplain
- TN24: Islands 40 & 41 Chute - Create, rehabilitate, and diversify secondary channels
- TN32AR14: Mosquito Lake Complex - Tributary enhancement

Completed or Underway Projects:

- AR10: Corona Lake - Restore and diversify floodplain water bodies (underway)
- AR12: Redman Point Bar - Create, rehabilitate, and diversify secondary channels (completed)
- AR13: Loosahatchie Bar - Create, rehabilitate, and diversify secondary channels (completed)
- AR8: Lookout Towhead - Create, rehabilitate, and diversify secondary channels (completed)
- TN17: Hatchie River Mouth - Tributary enhancement (underway)
- TN19: Richardson's Landing Dikes - Create, rehabilitate, and diversify secondary channels (underway)
- TN23: Hickman Bar/ Randolph Point - Create, rehabilitate, and diversify secondary channels (completed)
- TN25: Robinson Crusoe Island - Augment aquatic connectivity with the floodplain (completed)

LMRRA Conservation Reach Study
Hatchie River to Loosahatchie - River Mile 775 to 736

LMRCC Restoration Sites	
AR8	Lookout Towhead
AR9	Dean Island Landing
AR10	Corona Lake
AR11	Brandywine Chute
AR12	Redman Point Bar
AR13	Loosahatchie Bar
TN16	Sunrise TH/Isl 34 Acquisition
TN17	Hatchie River Mouth
TN18	Mouth of Hatchie River Acq
TN19	Richardson's Landing Dikes
TN20	Island 35 / Densford Bar Acq
TN21	Thweatt Chute
TN22	Shelby Forest Lakes
TN23	Hickman Bar/ Randolph Point
TN24	Islands 40 & 41 Chute
TN25	Robinson Crusoe Island
TN32AR14	Mosquito Lake Complex



Prepared by LMRCC 06Oct2014

Reach #3: Island 62/63 Reach

River Miles: RM 650 – 618 (32 miles)

Description: From just above Kangaroo Pt. Dikes to the crossing below Island 67 Dikes lays a diverse ecosystem. Two prominent features include the Jackson and Sunflower cut-offs that formed DeSoto and Mellwood Lakes (e.g., oxbow lakes). Also included are large tracts of bottomland hardwood forests within the batture, and several secondary channels, river crossings and pools, old bendways, and wide overbank areas which extend 2-12 miles between the levees. Dikes have been notched at Island 63, Kangaroo Pt., and Below Ludlow, along with pre- and post-construction surveys.

T&E Species: Ten active interior least tern colonies and fat pocketbook mussel shells have been observed. The reach has good potential for pallid sturgeon.

Public Access: Access from the boat ramp at Island 63 Chute.

LMRCC Projects: 15 projects have been identified in this reach, including dike notching, lake restoration, and secondary channel restoration/habitat enhancement)

- Create, rehabilitate, and diversify secondary channels (9 projects)
- Restore and diversify floodplain water bodies (5 projects)
- Improve recreational access (1 Project)

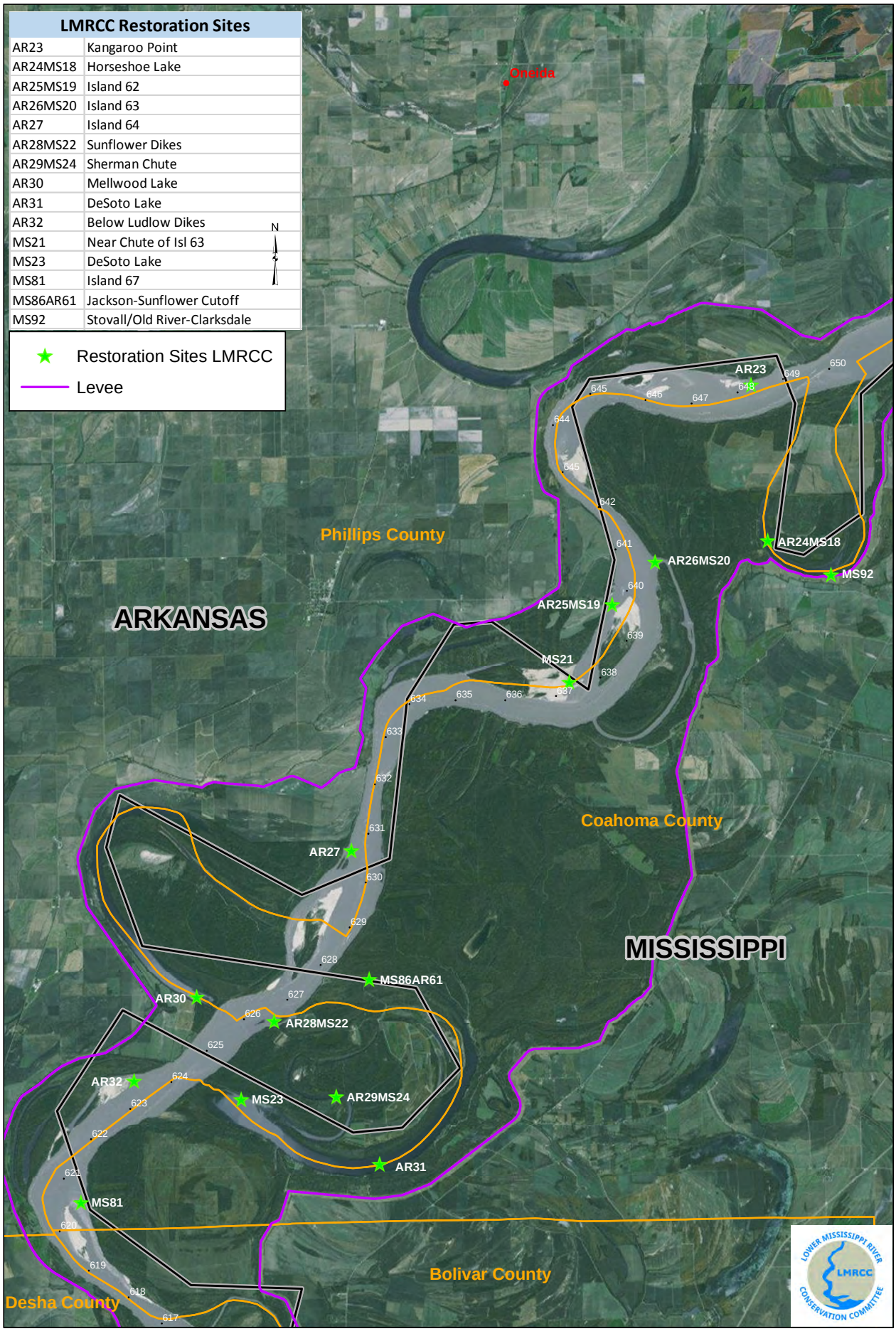
Project specifics noted on map:

- AR24MS18: Horseshoe Lake - Restore and diversify floodplain water bodies
- AR27: Island 64 - Create, rehabilitate, and diversify secondary channels
- AR28MS22: Sunflower Dikes - Create, rehabilitate, and diversify secondary channels
- AR29MS24: Sherman Chute - Create, rehabilitate, and diversify secondary channels
- AR30: Mellwood Lake - Restore and diversify floodplain water bodies
- AR31: DeSoto Lake - Restore and diversify floodplain water bodies
- MS23: DeSoto Lake - Restore and diversify floodplain water bodies
- MS81 Island 67 - Create, rehabilitate, and diversify secondary channels
- MS86AR61: Jackson-Sunflower Cutoff - Restore and diversify floodplain water bodies
- MS92: Stovall/Old River-Clarksdale - Improve recreational access

Completed or Underway Projects:

- AR23: Kangaroo Point - Create, rehabilitate, and diversify secondary channels (underway)
- AR25MS19: Island 62 - Create, rehabilitate, and diversify secondary channels (underway)
- AR26MS20: Island 63 - Create, rehabilitate, and diversify secondary channels (complete)
- AR32: Below Ludlow Dikes - Create, rehabilitate, and diversify secondary channels (underway)
- MS21 Near Chute of Island 63 - Create, rehabilitate, and diversify secondary channels (complete)

LMRRA Conservation Reach Study
Island 62/63 - River Mile 650 to 618



LMRCC Restoration Sites	
AR23	Kangaroo Point
AR24MS18	Horseshoe Lake
AR25MS19	Island 62
AR26MS20	Island 63
AR27	Island 64
AR28MS22	Sunflower Dikes
AR29MS24	Sherman Chute
AR30	Mellwood Lake
AR31	DeSoto Lake
AR32	Below Ludlow Dikes
MS21	Near Chute of Isl 63
MS23	DeSoto Lake
MS81	Island 67
MS86AR61	Jackson-Sunflower Cutoff
MS92	Stovall/Old River-Clarksdale

Prepared by LMRCC 06/Oct/2014

Reach #4: Arkansas River

River Miles: RM 599 – 556 (43 miles)

Description: Beginning at the mouth of the White River, this reach extends 43 miles to Choctaw Bar Chute. This complex reach is rich in diverse ecosystems, which encompasses the Caulk cut-off that formed Lake Whittington, one of the larger batture lakes in the lower Mississippi River. Also included are several secondary channels, river crossings and pools, and old bendways. A large expanse of floodplain is contained within this reach, ranging from 4-13 miles between the levees. Dike notching along with pre- and post-project surveys have been conducted at Below Prentiss and Catfish Point. Great River Road State Park is located in this reach.

T&E Species: Nine active interior least tern colonies have been observed. The reach has good potential for pallid sturgeon.

Public Access: Access from Terrene Lodge, Rosedale Harbor, and Easton Lodge.

LMRCC Projects: 14 projects already identified in this reach, including secondary channel restoration, dike notching, lake restoration and gravel bar conservation

- Create, rehabilitate, and diversify secondary channels (6 Projects)
- Enhance main channel habitat diversity (3 Projects)
- Restore and diversify floodplain water bodies (4 Projects)
- Improve recreational access (1 Project)

Project specifics noted on map:

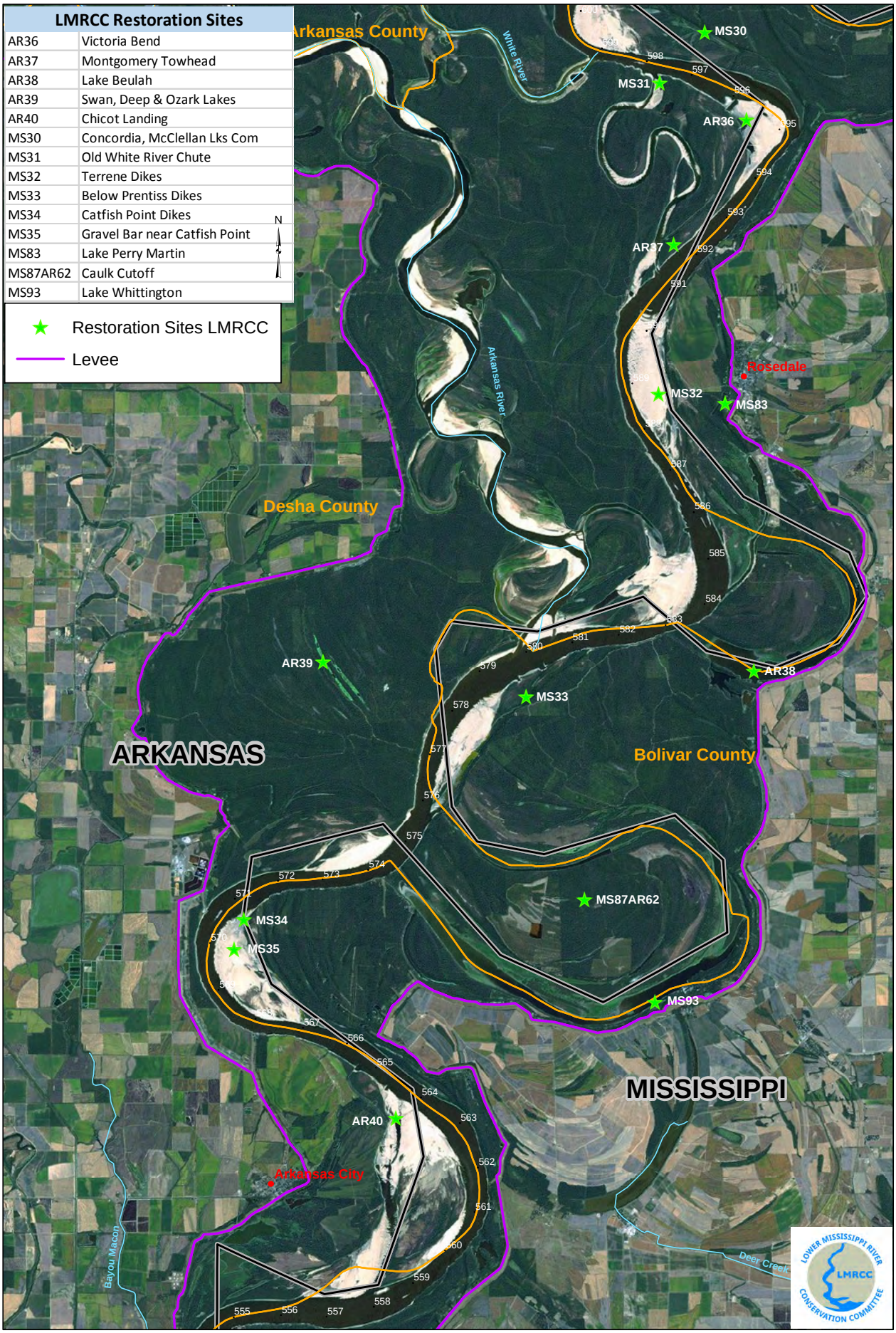
- AR37: Montgomery Towhead - Enhance main channel habitat diversity
- AR38: Lake Beulah - Enhance main channel habitat diversity
- AR39: Swan, Deep & Ozark Lakes - Restore and diversify floodplain water bodies
- MS30: Concordia Island - Restore and diversify floodplain water bodies
- MS31: Old White River Chute - Create, rehabilitate, and diversify secondary channels
- MS35: Gravel Bar near Catfish Point - Enhance main channel habitat diversity
- MS87AR62: Caulk Cutoff - Restore and diversify floodplain water bodies
- MS93: Lake Whittington - Improve recreational access

Completed or Underway Projects:

- AR36: Victoria Bend - Create, rehabilitate, and diversify secondary channels (underway)
- AR40: Chicot Landing - Create, rehabilitate, and diversify secondary channels (complete)
- MS32: Terrene Dikes - Create, rehabilitate, and diversify secondary channels (underway)
- MS33: Below Prentiss Dikes - Create, rehabilitate, and diversify secondary channels (complete)
- MS34: Catfish Point Dikes - Create, rehabilitate, and diversify secondary channels (complete)
- MS83: Lake Perry Martin - Restore and diversify floodplain water bodies (complete)

LMRRA Conservation Reach Study
Arkansas River - River Mile 599 to 556

LMRCC Restoration Sites	
AR36	Victoria Bend
AR37	Montgomery Towhead
AR38	Lake Beulah
AR39	Swan, Deep & Ozark Lakes
AR40	Chicot Landing
MS30	Concordia, McClellan Lks Com
MS31	Old White River Chute
MS32	Terrene Dikes
MS33	Below Prentiss Dikes
MS34	Catfish Point Dikes
MS35	Gravel Bar near Catfish Point
MS83	Lake Perry Martin
MS87AR62	Caulk Cutoff
MS93	Lake Whittington



Prepared by LMRCC 06/Oct/2014

Reach #5: Worthington-Pittman

River Miles: RM 524 – 490 (34 miles)

Description: This reach begins above Kentucky Bend and extends to a short distance above Lake Providence, LA. These 34 miles of the LMR encompass a diverse and complex mix of habitats including chutes/side channels (e.g., Cornfield Chute, Moon Chute, Matthews Bend, Caroline Chute, Bunches Cutoff, Old River Chute), floodplain lakes (e.g., Snag Lake, Gassoway Lake, Doe Lake, plus many borrow pits), Old River oxbow, islands, wide expanses of batture (e.g., Island 88, Worthington Towhead, Sara Island, Cracraft Towhead, Pittman Island, Duncansby Towhead, and Wilson Point), numerous wetlands, and extensive forested areas and agricultural fields. The reach also includes dike fields, crossovers, and river bends. It encompasses two cut-offs (Worthington and Sarah) with levees set back creating a diverse floodplain with bottomland hardwood forest, large lakes, and other water bodies. In this reach, there are 2-9 miles between the levees.

T&E Species: Six active interior least tern colonies have been observed in this reach and it has good potential for pallid sturgeon.

Public Access: Boat ramps provide access to this reach.

LMRCC Projects: 18 projects already identified in this reach .

- Create, rehabilitate, and diversify secondary channels (10 Projects)
- Enhance main channel habitat diversity (1 Project)
- Restore and diversify floodplain water bodies (1 Project)
- Augment aquatic connectivity with the floodplain (5 Projects)
- Improve recreational access (1 Project)

Project specifics noted on map:

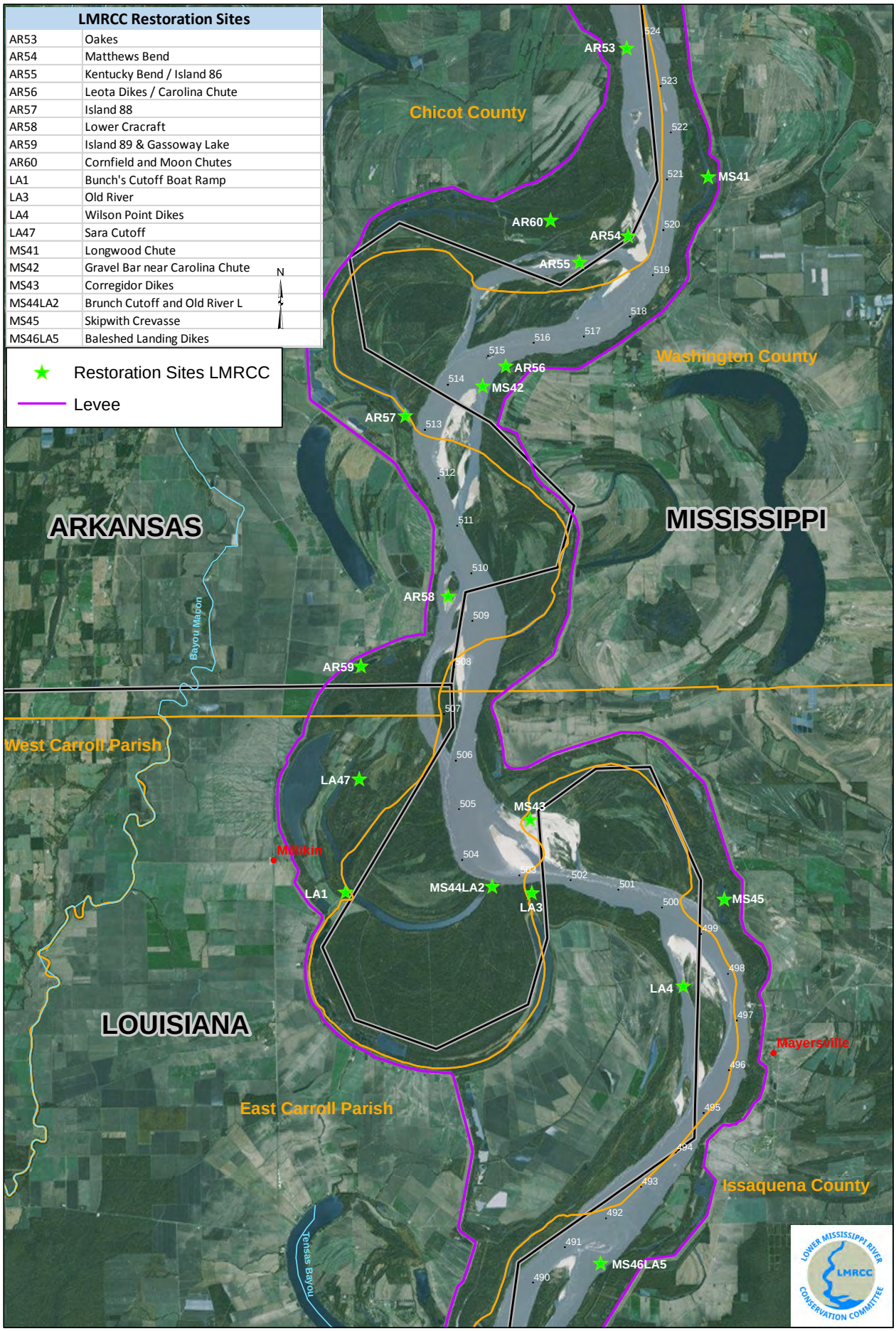
- AR53: Oakes - Create, rehabilitate, and diversify secondary channels
- AR54: Matthews Bend - Augment aquatic connectivity with the floodplain
- AR56: Leota Dikes / Carolina Chute - Create, rehabilitate, and diversify secondary channels
- AR57: Island 88 - Augment aquatic connectivity with the floodplain
- AR58: Lower Cracraft - Create, rehabilitate, and diversify secondary channels
- AR59: Island 89 & Gassoway Lake - Create, rehabilitate, and diversify secondary channels
- AR60: Cornfield and Moon Chutes - Create, rehabilitate, and diversify secondary channels
- LA1: Bunch's Cutoff Boat Ramp - Improve recreational access
- LA3: Old River - Augment aquatic connectivity with the floodplain
- LA4: Wilson Point Dikes - Create, rehabilitate, and diversify secondary channels
- LA47: Sara Cutoff - Restore and diversify floodplain water bodies
- MS41: Longwood Chute - Augment aquatic connectivity with the floodplain
- MS42: Gravel Bar near Carolina Chute - Enhance main channel habitat diversity
- MS43: Corregidor Dikes - Create, rehabilitate, and diversify secondary channels
- MS44LA2: Brunch’s Cutoff and Old River- Create, rehabilitate, and diversify secondary channels
- MS45: Skipwith Crevasse - Augment aquatic connectivity with the floodplain

Completed or Underway Projects:

- AR55: Kentucky Bend / Island 86 - Create, rehabilitate, and diversify secondary channels (underway)
- MS46LA5: Baleshed Landing Dikes - Create, rehabilitate, and diversify secondary channels (underway)

LMRRA Conservation Reach Study
Worthington-Pittman - River Mile 524 to 490

LMRCC Restoration Sites	
AR53	Oakes
AR54	Matthews Bend
AR55	Kentucky Bend / Island 86
AR56	Leota Dikes / Carolina Chute
AR57	Island 88
AR58	Lower Cracraft
AR59	Island 89 & Gassoway Lake
AR60	Cornfield and Moon Chutes
LA1	Bunch's Cutoff Boat Ramp
LA3	Old River
LA4	Wilson Point Dikes
LA47	Sara Cutoff
MS41	Longwood Chute
MS42	Gravel Bar near Carolina Chute
MS43	Corregidor Dikes
MS44LA2	Brunch Cutoff and Old River L
MS45	Skipwith Crevasse
MS46LA5	Baleshed Landing Dikes



Prepared by LMRCC 06/Oct/2014

Reach #6: Palmyra

River Miles: RM 431 – 398 (33 miles)

Description: Just below Vicksburg, MS the reach begins just upstream of Below Racetrack dikes and extends through Below Grand Gulf Dikes. Two prominent features include Yucatan Lake (an oxbow lake) and an extremely complex, wide batture (e.g., 1.5-13 miles between the levees). Palmyra, a ten-mile long secondary channel, was created from the Diamond cut-off and connects to numerous floodplain lakes. The reach also encompasses diverse ecosystems containing several secondary channels, river crossings and pools and old bendways.

T&E Species: Six active interior least tern colonies have been observed in this reach and its has good potential for pallid sturgeon.

Public Access: Access from the boat ramp at Grand Gulf and La Tourneau.

LMRCC Projects: 12 projects already identified in this reach (e.g., chute restoration, lake assessment/restoration, dike notching, gravel bar conservation and recreational access)

- Create, rehabilitate, and diversify secondary channels (1 Project)
- Enhance main channel habitat diversity (3 Projects)
- Restore and diversify floodplain water bodies (3 Projects)
- Augment aquatic connectivity with the floodplain (2 Projects)
- Improve recreational access (3 Projects)

Project specifics noted on map:

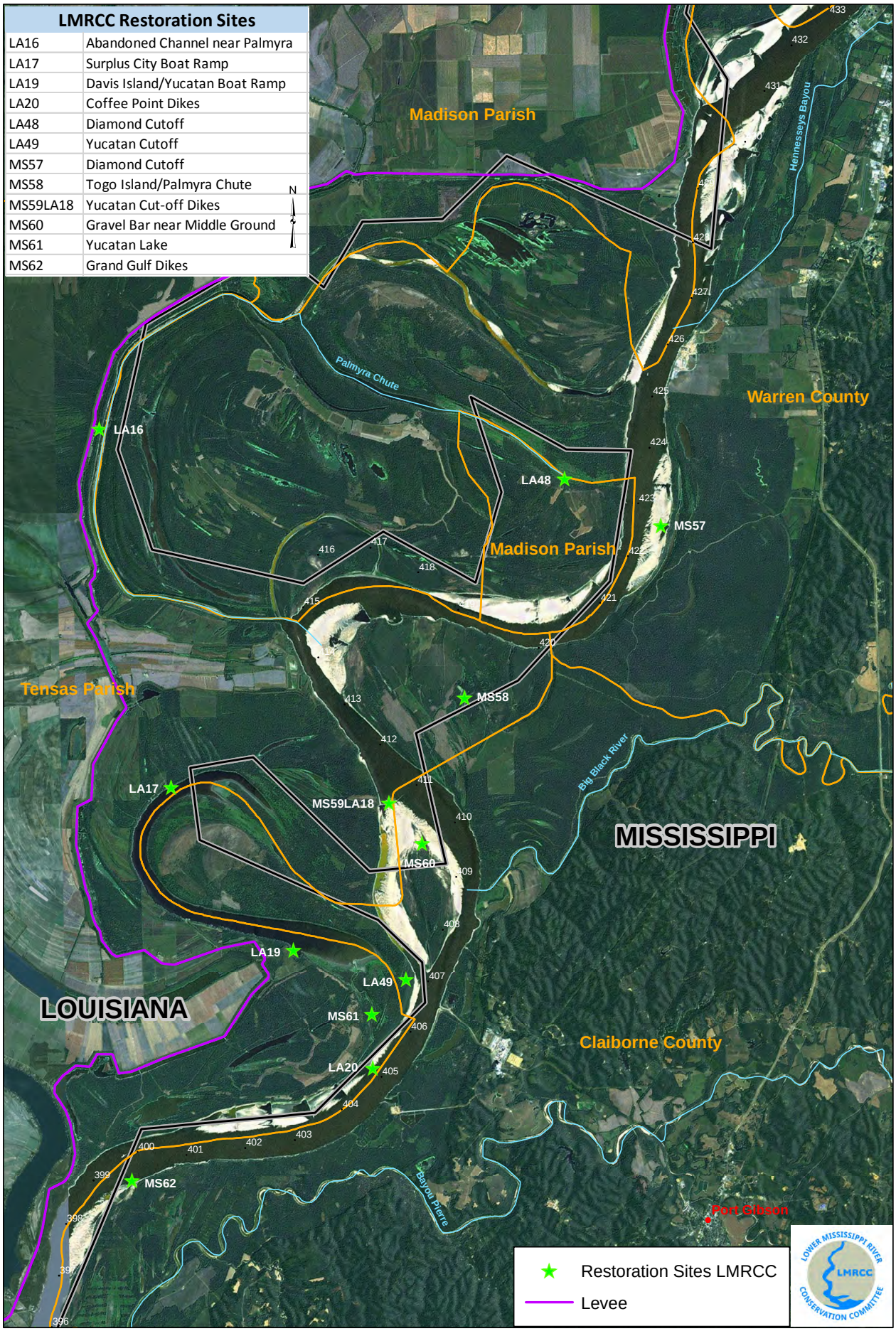
- LA16: Abandoned Channel near Palmyra - Improve recreational access
- LA17: Surplus City Boat Ramp - Improve recreational access
- LA19: Davis Island/Yucatan Boat Ramp - Improve recreational access
- LA48: Diamond Cutoff -Restore and diversify floodplain water bodies
- MS58: Togo Island/Palmyra Chute - Restore and diversify floodplain water bodies
- MS59LA18: Yucatan Cut-off Dikes - Create, rehabilitate, and diversify secondary channels
- MS60: Gravel Bar near Middle Ground - Enhance main channel habitat diversity
- MS61: Yucatan Lake - Augment aquatic connectivity with the floodplain
- MS62: Grand Gulf Dikes - Enhance main channel habitat diversity

Completed or Underway Projects:

- LA20: Coffee Point Dikes - Augment aquatic connectivity with the floodplain (underway)
- MS57: Diamond Cutoff - Enhance main channel habitat diversity (underway)
- LA49: Yucatan Cutoff - Restore and diversify floodplain water bodies (underway)

LMRRA Conservation Reach Study
Palmyra - River Mile 431 to 398

LMRCC Restoration Sites	
LA16	Abandoned Channel near Palmyra
LA17	Surplus City Boat Ramp
LA19	Davis Island/Yucatan Boat Ramp
LA20	Coffee Point Dikes
LA48	Diamond Cutoff
LA49	Yucatan Cutoff
MS57	Diamond Cutoff
MS58	Togo Island/Palmyra Chute
MS59LA18	Yucatan Cut-off Dikes
MS60	Gravel Bar near Middle Ground
MS61	Yucatan Lake
MS62	Grand Gulf Dikes



Prepared by LMRCC 06/Oct/2014

Reach #7: Lake Mary

River Miles: RM 360 – 322 (38 miles)

Description: The reach begins just above Natchez Island Dikes (just below Natchez, MS) and extends to below the Lake Mary outlet and proposed Union Point dikes. Lake Mary and Glasscock Cutoff are the major habitat features in this reach. Also included are secondary channels, river crossings and pools, channels, old bendways and a wide batture that ranges 2.5-14 miles between the west levee and the high ground on the east. Three Rivers Wildlife Management Area is also located in this reach. While there are several notched dikes in the reach, there are no known surveyed reaches.

T&E Species: Four active interior least tern colonies have been observed in this reach and there is good potential for pallid sturgeon. Critical Habitat for the Louisiana black bear has been designated in the Tensas River Basin near this reach.

Public Access: Access from the boat ramp at Natchez Front and Lake Mary Road boat ramp.

LMRCC Projects: 13 projects have been identified in this reach – dike notching, improve aquatic habitat, recreational access, chute restoration, lake restoration.

- Create, rehabilitate, and diversify secondary channels (4 Projects)
- Enhance main channel habitat diversity (4 Projects)
- Restore and diversify floodplain water bodies (2 Projects)
- Augment aquatic connectivity with the floodplain (1 Project)
- Improve recreational access (2 Projects)

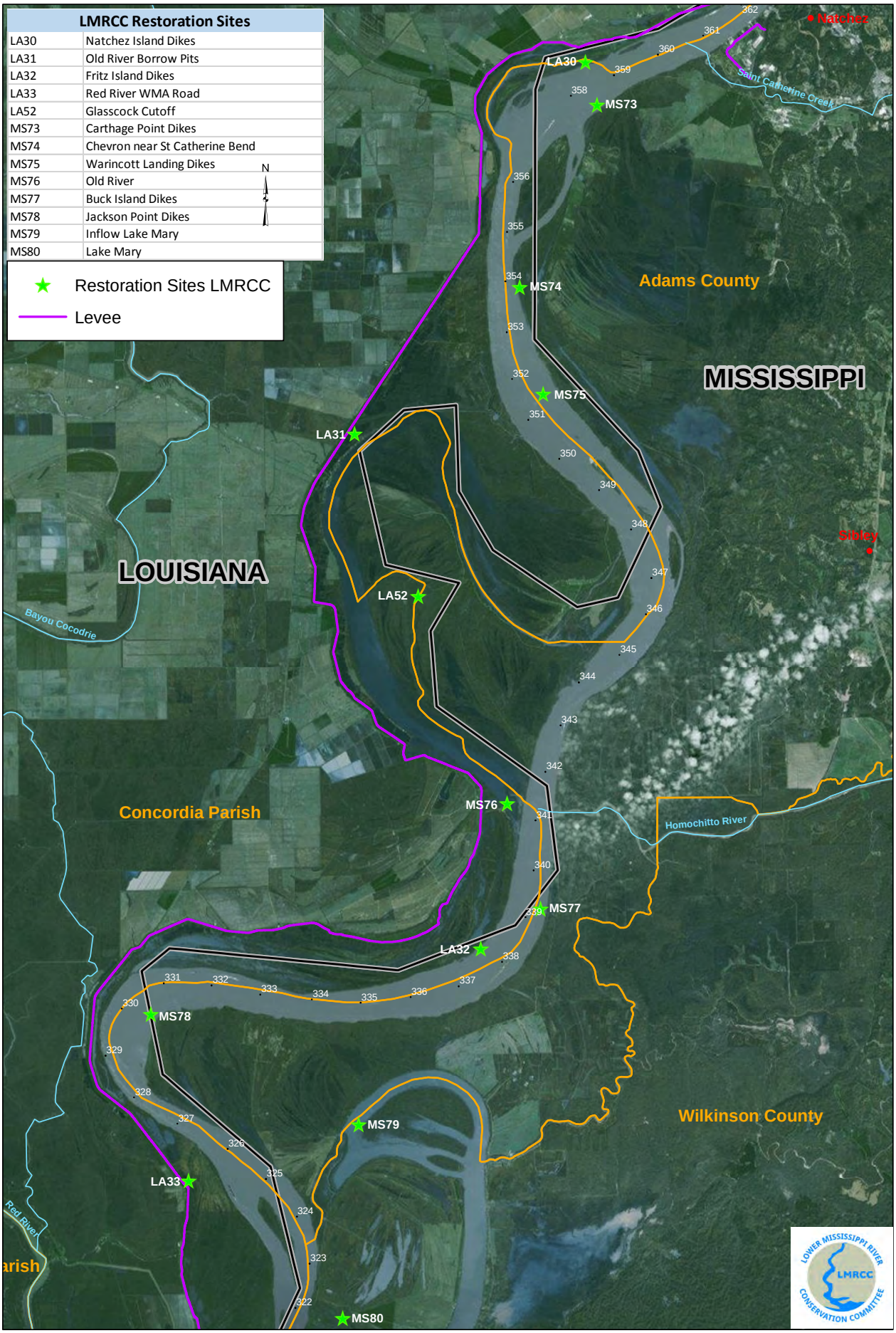
Project specifics noted on map:

- LA30: Natchez Island Dikes - Enhance main channel habitat diversity
- LA31: Old River Borrow Pits - Improve recreational access
- LA33: Red River WMA Road - Improve recreational access
- LA52: Glasscock Cutoff - Restore and diversify floodplain water bodies
- MS73: Carthage Point Dikes - Create, rehabilitate, and diversify secondary channels
- MS74: Chevron near St Catherine Bend - Enhance main channel habitat diversity
- MS76: Old River - Create, rehabilitate, and diversify secondary channels
- MS78: Jackson Point Dikes - Enhance main channel habitat diversity
- MS79: Inflow Lake Mary - Restore and diversify floodplain water bodies
- MS80: Lake Mary - Augment aquatic connectivity with the floodplain

Completed or Underway Projects:

- LA32: Fritz Island Dikes - Create, rehabilitate, and diversify secondary channels (underway)
- MS75: Warincott Landing Dikes - Create, rehabilitate, and diversify secondary channels (underway)
- MS77: Buck Island Dikes - Enhance main channel habitat diversity (underway)

LMRRA Conservation Reach Study
Lake Mary - River Mile 360 to 322



Prepared by LMRCC 06/Oct/2014

Reach #8: Raccourci Cutoff

River Miles: RM 300 – 265 (35 miles)

Description: The reach begins at the upper end of Raccourci Cutoff to St. Francisville, LA. First major component of this reach is the Raccourci Cutoff and its associated batture. The cutoff extends nearly 14 miles and is connected to Monday Lake. Other lakes within the batture include Green, Sugar House, Limeless, and Shaw Lakes. Sloughs, borrow pits, wetlands, extensive forested area, islands and side channels also add complexity to this area. Second major component includes the Morganza Floodway and Control Structure that can be operated to mitigate flooding in Baton Rouge, LA. Third major component is the large expanse of batture along the east bank above St. Francisville, LA. A few small tributaries (i.e., Bayou Sara) empty into the river in this area. Wetlands, small lakes, and sloughs add habitat diversity throughout this mostly forested batture. In this reach, there are 1-10 miles between the levees.

T&E Species: One active interior least tern colony has been observed in this reach. This reach overlies part of the Upper Atchafalaya River Basin section of Critical Habitat for the Louisiana black bear.

Public Access: There is a boat ramp located about 5.5 miles upstream from the reach.

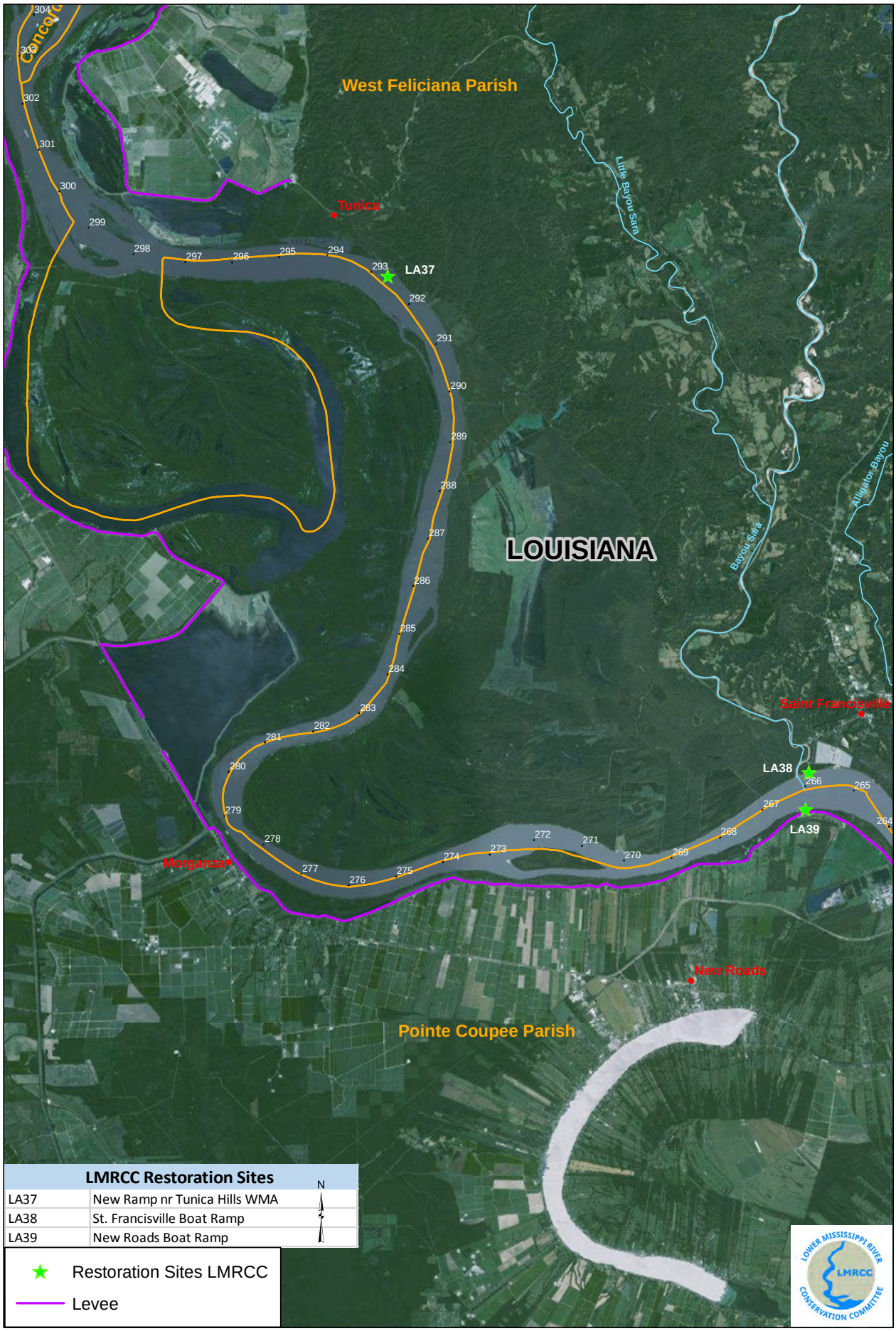
LMRCC Projects: Only three projects to improve recreational access were identified.

- Improve recreational access (3 Projects)

Project specifics noted on map:

- LA37: New Ramp near Tunica Hills WMA - Improve recreational access
- LA38: St. Francisville Boat Ramp - Improve recreational access
- LA39: New Roads Boat Ramp - Improve recreational access

LMRRA Conservation Reach Study
Raccourci Cutoff - River Mile 300 to 265



Prepared by LMRCC 06/Oct/2014

APPENDIX C

Aquatic Habitat Restoration Studies

Recommendation HRMP 2

Project ID	Project Name	Primary Project Focus	Project State	Upper RM
AR42	Point Comfort	Augment aquatic connectivity with the floodplain	AR	548
AR43	Lake Paradise	Augment aquatic connectivity with the floodplain	AR	548
AR51	Lake Port Reconnection	Augment aquatic connectivity with the floodplain	AR	527
KY02	Upper Island 1 Dikes (Backwater)	Augment aquatic connectivity with the floodplain	KY	948
MS06	Midway Lake	Augment aquatic connectivity with the floodplain	MS	694
MS52	Chotard Lake	Augment aquatic connectivity with the floodplain	MS	461
MS65	Rodney Lake Assessment	Augment aquatic connectivity with the floodplain	MS	389
MS71	Giles Bend	Augment aquatic connectivity with the floodplain	MS	367
TN01	Tiptonville Chute	Augment aquatic connectivity with the floodplain	TN	879
TN06	Robert E. Everett Lake	Augment aquatic connectivity with the floodplain	TN	838
TN10	Nebraska Point Dikes	Augment aquatic connectivity with the floodplain	TN	815
TN13	Elmot Bar and Kate Aubrey Acq	Augment aquatic connectivity with the floodplain	TN	784
TN15	Cold Creek Chute	Augment aquatic connectivity with the floodplain	TN	783
TN33MS01	Mud & Horn Lake Complex	Augment aquatic connectivity with the floodplain	TN	725
TN34	Open Lake - Lower Forked Deer Acquisition	Augment aquatic connectivity with the floodplain	TN	801
AR01	Tamm Bend	Create, rehabilitate, and diversify secondary channels	AR	821
AR02	Wright's Point	Create, rehabilitate, and diversify secondary channels	AR	820
AR03	Island 25 Bend	Create, rehabilitate, and diversify secondary channels	AR	805
AR04	Island 27	Create, rehabilitate, and diversify secondary channels	AR	800
AR16	Cat Island	Create, rehabilitate, and diversify secondary channels	AR	711
AR19	Commerce Dikes/Rabbit Island	Create, rehabilitate, and diversify secondary channels	AR	694
AR21MS15	Prairie Point	Create, rehabilitate, and diversify secondary channels	AR	669
AR22	Montezuma Towhead	Create, rehabilitate, and diversify secondary channels	AR	655
AR33	Head of Island 69/Below Knowlton	Create, rehabilitate, and diversify secondary channels	AR	616
AR34	Island 69 Dikes	Create, rehabilitate, and diversify secondary channels	AR	614
AR46	Leland Bar	Create, rehabilitate, and diversify secondary channels	AR	536
AR47	Leland and Whiskey Chutes	Create, rehabilitate, and diversify secondary channels	AR	537
AR50	Lake Port Towhead	Create, rehabilitate, and diversify secondary channels	AR	529
KY14	Kentucky Pt. Dikes	Create, rehabilitate, and diversify secondary channels	KY	888
LA09	Cottonwood Bar SC	Create, rehabilitate, and diversify secondary channels	LA	471
LA23	Secondary Channel Opposite Cottage Bend 390	Create, rehabilitate, and diversify secondary channels	LA	390
LA24	Browns Field Dikes	Create, rehabilitate, and diversify secondary channels	LA	388
MO11	Donaldson Point	Create, rehabilitate, and diversify secondary channels	MO	907
MO13	Island #11	Create, rehabilitate, and diversify secondary channels	MO	882
MO15	Beaver Lake	Create, rehabilitate, and diversify secondary channels	MO	872
MO22	Boat Club Chute	Create, rehabilitate, and diversify secondary channels	MO	849
MO24	Island 18	Create, rehabilitate, and diversify secondary channels	MO	836
MO25	Island 20	Create, rehabilitate, and diversify secondary channels	MO	832
MO26	Flow to Ashland Towhead	Create, rehabilitate, and diversify secondary channels	MO	833
MO27	Island 15	Create, rehabilitate, and diversify secondary channels	MO	853
MS10	Bordeaux Point Dikes	Create, rehabilitate, and diversify secondary channels	MS	682
MS11	Below Walnut Bend Dikes	Create, rehabilitate, and diversify secondary channels	MS	676.5
MS25	Cessions Towhead	Create, rehabilitate, and diversify secondary channels	MS	616
MS26	Island 70 Dikes	Create, rehabilitate, and diversify secondary channels	MS	609
MS48	Ajax Bar Dikes	Create, rehabilitate, and diversify secondary channels	MS	485
MS50	Arcadia Point Dikes	Create, rehabilitate, and diversify secondary channels	MS	471
MS53	Paw Paw Bend	Create, rehabilitate, and diversify secondary channels	MS	447
MS54LA13	Tarpley Island Dike (False Point Dikes)	Create, rehabilitate, and diversify secondary channels	MS	439.5
MS64LA22	Bondurant Towhead Dikes	Create, rehabilitate, and diversify secondary channels	MS	395
MS67LA25	Spithead Towhead	Create, rehabilitate, and diversify secondary channels	MS	387
MS69LA27	Waterproof Dikes	Create, rehabilitate, and diversify secondary channels	MS	378
MS70	Chevron below Fairchilds Bend RM371	Create, rehabilitate, and diversify secondary channels	MS	371
MS82	Anconia	Create, rehabilitate, and diversify secondary channels	MS	528
TN02	Lee Towhead	Create, rehabilitate, and diversify secondary channels	TN	859
TN03	Hathaway Dikes	Create, rehabilitate, and diversify secondary channels	TN	855
TN04	Blaker Towhead	Create, rehabilitate, and diversify secondary channels	TN	846
TN07	Island 21, North End	Create, rehabilitate, and diversify secondary channels	TN	829
TN08	Island 21 secondary Channel	Create, rehabilitate, and diversify secondary channels	TN	829
TN11AR05	Ashport Golddust Dikes Bar	Create, rehabilitate, and diversify secondary channels	AR	797
TN12AR06	Kate Aubrey Towhead	Create, rehabilitate, and diversify secondary channels	TN	791
TN26	Ensley Bar/Dismal Point Dikes	Create, rehabilitate, and diversify secondary channels	TN	726
TN27	Armstrong Bar Hydrology	Create, rehabilitate, and diversify secondary channels	TN	720
TN30	Plum Point Dikes	Create, rehabilitate, and diversify secondary channels	TN	786
TN31	Plum Point Acquisition	Create, rehabilitate, and diversify secondary channels	TN	790
MS72	Marengo Bend	Create/rehabilitate wetlands	MS	365
TN28	Armstrong Bar Acquisition	Create/rehabilitate wetlands	TN	720
AR07	Island 30	Enhance main channel habitat diversity	AR	787
AR15	Engineer's Bar	Enhance main channel habitat diversity	AR	734
AR18	Basket Bar	Enhance main channel habitat diversity	AR	699
AR20	St. Francis Dikes	Enhance main channel habitat diversity	AR	671
AR35	Henrico Dikes	Enhance main channel habitat diversity	AR	603
AR44	Tarpley Cutoff	Enhance main channel habitat diversity	AR	538
AR45	Point Chicot and Bachelor Bend	Enhance main channel habitat diversity	AR	540

AR52	Walnut Point	Enhance main channel habitat diversity	AR	525
MO01	Birds Point Sandbar	Enhance main channel habitat diversity	MO	953
MO12	Hotch Kiss Bend	Enhance main channel habitat diversity	MO	897
MO16	Stewart Towhead	Enhance main channel habitat diversity	MO	873
MO19	Across from Lee TH/ Isl 14	Enhance main channel habitat diversity	MO	860
MO20	Robinson Bayou	Enhance main channel habitat diversity	MO	854
MO23	Caruthersville-Linwood	Enhance main channel habitat diversity	MO	846
MS03	Gravel Bar near Cat Island RM710	Enhance main channel habitat diversity	MS	710
MS04	Pickett Dike Field	Enhance main channel habitat diversity	MS	705
MS07	Gravel Bar near Midway Lake RM693	Enhance main channel habitat diversity	MS	693
MS09	Gravel Bar near Bordeaux Pt RM682	Enhance main channel habitat diversity	MS	682
MS13	Flower Lake Bar	Enhance main channel habitat diversity	MS	668
MS14	Gravel Bar near Prairie Point RM 667	Enhance main channel habitat diversity	MS	667
MS16	Montezuma Bar	Enhance main channel habitat diversity	MS	658
MS17	Friars Point	Enhance main channel habitat diversity	MS	652
MS27	Gravel Bar near Island 70 rm608	Enhance main channel habitat diversity	MS	608
MS29	Smith Point Dikes	Enhance main channel habitat diversity	MS	
MS37	Ashbrook Cutoff	Enhance main channel habitat diversity	MS	548
MS38	Ashbrook-Miller Bend Dikes	Enhance main channel habitat diversity	MS	548
MS40	Gravel Bar near Anconia RM528	Enhance main channel habitat diversity	MS	528
MS47LA6	Ben Lomond Dikes	Enhance main channel habitat diversity	MS	488.5
MS51	Tennessee Bar Dikes	Enhance main channel habitat diversity	MS	467
MS55	Gravel Bar near Tarpley Island RM439 (near False Point)	Enhance main channel habitat diversity	MS	439
MS68	Chevron near Coles Island RM382	Enhance main channel habitat diversity	MS	382
TN14	Keyes Point Dikes	Enhance main channel habitat diversity	TN	792
TN09	Moss Island Acquisition	Enhance terrestrial habitat	TN	824
TN29	Open Lake - Obion River	Enhance terrestrial habitat	TN	817
AR17	Porter Lake Dikes	Restore and diversify floodplain water bodies	AR	703
AR41	Old River	Restore and diversify floodplain water bodies	AR	549.5
AR48	Beaver Lake	Restore and diversify floodplain water bodies	AR	534
AR49	Lake Lee	Restore and diversify floodplain water bodies	AR	529
LA08	Borrow Pits near Stump Hole	Restore and diversify floodplain water bodies	LA	484
LA34	Red River WMA Borrow Pits	Restore and diversify floodplain water bodies	LA	327
LA36	Borrow Pits near Shreves Bar	Restore and diversify floodplain water bodies	LA	302.5
LA40	Devil's Swamp	Restore and diversify floodplain water bodies	LA	235
LA50MS89	Rodney Cutoff	Restore and diversify floodplain water bodies	LA - MS	390
LA51	Giles Cutoff	Restore and diversify floodplain water bodies	LA	370
MO14	Pt. Pleasant Chute	Restore and diversify floodplain water bodies	MO	878
MO18	Near Little Crypress Bend	Restore and diversify floodplain water bodies	MO	867
MS05	Old River Lake, Island 53	Restore and diversify floodplain water bodies	MS	702
MS08	Old River Lake, Rabbit Island	Restore and diversify floodplain water bodies	MS	690
MS12	Duck, Mud, North, and Flower Lakes	Restore and diversify floodplain water bodies	MS	670
MS28	Old River Lake, Island 71	Restore and diversify floodplain water bodies	MS	604
MS39	Lake Ferguson	Restore and diversify floodplain water bodies	MS	544
MS56	Lake Centennial	Restore and diversify floodplain water bodies	MS	438
MS66	Rodney Lake Weir	Restore and diversify floodplain water bodies	MS	387
MS84	Tunica Lake	Restore and diversify floodplain water bodies	MS	678
MS85	Hardin Point Cutoff	Restore and diversify floodplain water bodies	MS	678
MS88AR63	Ashbrook - Tarpley Cutoff	Restore and diversify floodplain water bodies	MS-AR	550
TN05	Island 18 Towhead	Restore and diversity secondary channels	TN	838
KY01	Mayfield Creek	Tributary enhancement	KY	950
MS36	Black Bayou	Tributary enhancement	MS	551
MS63	Bayou Pierre	Tributary enhancement	MS	395

Additional Proposal Information

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LMR Conservation Plan Final USACE CIP 23 July 2013.pdf

MVD/ERDC

MISSISSIPPI VALLEY DIVISION /
ENGINEER RESEARCH AND DEVELOPMENT
CENTER – ENVIRONMENTAL LABORATORY

US Army Corps of Engineers®

Conservation Plan for the Interior Least Tern, Pallid Sturgeon, and Fat Pocketbook Mussel in the Lower Mississippi River (Endangered Species Act, Section 7(a)(1))

July 23, 2013

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EXECUTIVE SUMMARY

Conservation Plan for the Interior Least Tern, Pallid Sturgeon, and Fat Pocketbook Mussel, in the Lower Mississippi River (Endangered Species Act, section 7(a)(1))

Section 7(a)(1) of the Endangered Species Act (ESA) requires all Federal agencies to use their authorities as appropriate to carry out programs for the conservation (i.e., recovery) of endangered and threatened species. For more than a decade the U.S. Army Corps of Engineers (USACE) has worked with the U.S. Fish & Wildlife Service (USFWS) and state conservation agencies to identify and resolve endangered species and ecosystem management issues associated with USACE civil works projects to provide flood risk management infrastructure and to facilitate navigation in the Lower Mississippi River (LMR). It has become apparent that the very programs that have most significantly affected the river are potentially the most important and cost-effective tools to maintain and enhance its ecological functions. This is accomplished by considering and incorporating ecological engineering opportunities during the design phase of channel improvement and channel maintenance projects. Early consideration of conservation designs results in localized improvements in habitat function and value, with little to no effect on flood risk management, navigation, or project cost. The USACE has also opportunistically implemented cost-effective secondary channel restoration actions in the LMR by sharing responsibilities and resources with partner agencies. Cumulatively, both the site-specific engineering action and the restoration opportunities have significantly benefitted the habitat baselines of endangered species associated with the LMR channel. Herein, the USACE outlines the programmatic mechanisms by which the Channel Improvement Program of the Mississippi River and Tributaries project is being utilized to implement conservation measures that maintain and improve habitat values within the LMR for recovery of endangered and other trust species inhabiting the river channel. This program has been developed under informal consultation with the USFWS, and complies with section 7(a)(1) of the ESA, USACE Environmental Operating Principles, Civil Works Ecosystem Restoration Policy (ER 1165-2-501), and supports the conservation intent of EO 13186 Responsibilities of Federal Agencies to Protect Migratory Birds.

PART I: INTRODUCTION

Background

The Lower Mississippi River (LMR) extends 953.5 miles from the confluence of the Ohio River to the Head of Passes where the river subdivides into several distributaries to the Gulf of Mexico. In response to the 1927 flood, the Mississippi River and Tributaries (MR&T) project was initiated by the USACE. The project consists of levees, revetments, flood storage reservoirs, and floodways to reduce flood risk, as well as dikes, and other river training structures in the channel to facilitate low-water navigation by towboats. Construction of the MR&T project, which still continues today, has resulted in one of the most highly engineered large river channels on the planet.

The construction of the Mississippi River levee system altered natural patterns of surface water drainage within the region and reduced the floodplain by over 80% (Baker et al. 1991). Channel engineering for navigation over the past 30 years has resulted in a gradual but significant loss of secondary channels and in the area of associated seasonally flooded in-channel habitats in the LMR. About 23 secondary channels and roughly 14,000 acres of associated higher elevation habitats have been lost in the LMR since the 1960's due to natural realignments and/or channel modifications, including closure dikes, conducted under the MR&T Project (Williams & Clouse 2003). Dikes constructed along the main channel have resulted in sediment accretion and loss of aquatic surface area during low water periods.

While the development of the Mississippi River for year-round navigation and flood protection has provided enormous economic benefit to the United States, it has also resulted in a general decrease of channel habitat complexity in the LMR (e.g., Williams & Clouse 2003). Cumulative impacts have affected three endangered species inhabiting the LMR: Interior least tern (ILT), pallid sturgeon (PS), and fat pocketbook mussel (FPM), all of which are dependent upon in-channel and seasonally flooded habitats.

Despite river engineering activities over the past century, the LMR has not experienced any known extirpations or extinctions of channel species, such as have occurred in other large rivers of the United States. There are several reasons for this: 1) the LMR remains unimpounded, experiencing a natural flood cycle hydrograph; 2) although size and quantity of sediment input to the system has been significantly reduced through bank protection and construction of multiple impoundments of all major LMR tributaries, large quantities of stored sediment are available in its large channel that are continuously reworked during flood cycles; 3) implementation of the Clean Water Act throughout the drainage basin has significantly improved water quality in the LMR; and 4) the proactive nature of USACE, specifically Mississippi Valley Division, in carrying out its continuing responsibilities under the Endangered Species Act. These factors all contribute to maintain the LMR channel as a highly functional and valuable fluvial ecosystem.

The current local status of the three endangered species in the LMR also reflects the ecological functionality and value of the river channel. Although considered endangered throughout their ranges, LMR populations of ILT and PS are wide-spread and locally common in the river channel. While there are no historical records of FPM from the LMR channel proper, it

was either present in low numbers and unreported, or it has invaded the channel in recent years due to developing favorable conditions. Although the ecological requirements of the three species are not completely understood, the aquatic habitats available in the LMR, including point bars, gravel bars, eroded shorelines, functional side channels, and forested backwaters in the batture, have provided, and continue to provide both direct and indirect benefits to the endangered species, and all other channel dependent species.

The USACE, Mississippi Valley Division (USACE-MVD) is responsible for construction and maintenance of the Mississippi River and Tributaries Project in the LMR, as well as for maintaining its ecological function. For more than a decade, the USACE-MVD LMR districts have been working with state and Federal partners to maintain habitat complexity and reduce impacts to trust species by developing and applying cost-effective engineering and best management practices to routine channel maintenance and construction activities in the LMR (e.g., USFWS 2012a; DuBowy 2011).

Purpose and Scope

This Conservation Plan (Plan) is being prepared pursuant to Section 7(a)(1) of the Endangered Species Act, as amended, which requires all Federal agencies to use their authorities to carry out programs for the conservation (i.e., recovery) of endangered and threatened species. The purpose of the Plan is to describe how the MR&T Channel Improvement Program can be utilized to conserve ILT, PS, and FPM in the LMR. This Plan also describes results of the MVD's efforts to implement monitoring and other conservation efforts with the goal of recovering the species in the LMR. Continued implementation of these activities to maintain and enhance LMR aquatic habitat diversity is the primary goal of the Plan. Specific conservation measures are recommended to meet the purpose and goal of the Plan, but are contingent upon opportunity and annual appropriations, and other authority and budgetary constraints.

The Channel Improvement Program civil works project encompasses the LMR channel within the jurisdiction of the MVD and the Memphis, Vicksburg, and New Orleans Engineer Districts. This Plan does not address issues related to other USACE regulatory responsibilities, water diversions, or the 45-ft channel below New Orleans. The PS range encompasses all of the LMR within the scope of the Plan; ILT range includes over 600 miles of the River above Baton Rouge, LA; known range of FPM includes over 400 miles of the channel above the Old River Control Complex. Customary yearly evaluations of effects of project construction at scattered sites along the river, without consideration of cumulative or system-wide effects, do not adequately address potential impacts to any of the three species. Therefore, a system-wide or landscape approach was taken in the analyses of Channel Improvement Program project effects on the PS, ILT, and FPM.

PART II: ENVIRONMENTAL SETTING

The Mississippi River is one of the world's largest alluvial river systems, having a drainage basin of 1,245,000 square miles, encompassing 41 percent of the contiguous United States and parts of two Canadian provinces. Worldwide, the Mississippi River ranks third in drainage area, seventh in length, and sixth in average discharge. The main stem of the river courses 2,348 miles from Lake Itasca in northern Minnesota to the Head of Passes. Above St. Louis, the river is impounded by 27 Locks and Dams. Between the mouths of the Missouri River at St. Louis, MO, and the Ohio River at Cairo, IL, is a 200-mile reach referred to as the Middle Mississippi River (MMR).

The Lower Mississippi River (LMR) begins at the confluence of the Mississippi and Ohio Rivers in southern Illinois and flows southward 955 miles in a meandering pattern to Head-of-Passes, LA, where the channel subdivides into several distributaries to the Gulf of Mexico. The LMR has two distinct reaches, although Schumm et al. (1994) further subdivides the LMR into 24 reaches based on geomorphology and channel maintenance activities. From Cairo at the mouth of the Ohio River (RM 953) south to Baton Rouge, the river has well-defined point bars and forested floodplains adjacent to the river (Baker et al. 1991). Minimum navigation channel is maintained at 9 feet, but is authorized for 12 feet. Below Baton Rouge, the river flows through the Deltaic Plain 235 miles to the Gulf. The channel is deeper to accommodate ocean-going traffic (45 feet deep navigation), and meander loops, sandbars, and floodplain are much reduced (Baker et al. 1991).

Geomorphology

The Lower Mississippi River Valley (LMRV) lies within the Central Gulf Coastal Plain physiographic province. A northward extending lobe, the Mississippi Embayment of this province follows the axis of the Mississippi Basin and comprises the northern part of the LMRV (Schumm et al. 1982). Virtually all LMRV landforms and deposits are the result of fluvial, Aeolian, or marine processes.

The LMRV varies in width between 40 and 110 miles and includes parts of Missouri, Illinois, Tennessee, Kentucky, Arkansas, Mississippi, and Louisiana. According MR&T (2012), the topography of the 53,000 square mile LMRV is characterized by a flat to slightly undulating surface underlain by alluvial and terrace deposits. Average floodplain elevations in the LMRV decline from about 325 feet mean sea level (msl) in extreme southern Illinois to about 40 feet msl at the northern edge of the deltaic plain. The average down valley slope is only 0.6 feet/mile. Average relief in the upper part of the LMRV is about 25 feet and declines progressively southward. Uplands bordering the LMRV typically attain elevations of about 200 feet above those of the adjacent floodplain. Upland elevations also steadily decline southward.

Soils in the LMRV range up to 300 feet in depth and consist mainly of sands and silt, grading progressively to very fine sands and silts in the lower portion of the area with extensive deposits of clay scattered through these formations. Typical of streams flowing through alluvial valleys, the LMR developed a highly sinuous course, creating numerous meander loops, bends, and oxbow lakes. The meandering characteristics of the present-day river may not have fully developed until about 5000 to 6000 years ago (Baker et al. 1991). Historically, the river shifted its channel frequently and

reworked parts of its alluvial meander belt, thus contributing to the complexity of the soils structure and hydrology of the area (Saucier 1994).

MR&T Project is a complex, comprehensive water resources project, which provides flood risk management within the alluvial valley and navigation improvement of the LMR. The primary elements of the MR&T Project include: levees, channel improvement features such as meander cutoffs, bank stabilization, dikes, dredging, floodways and diversion structures, and tributary basin improvements. The historical, present-day, and future morphology of the LMR reflects an integration of all these features combined with natural factors such as floods and droughts, hurricanes, tectonic activity, geologic outcrops, climatic variability, and sea level rise and other anthropogenic activities such as gravel mining. The geomorphology of present-day LMR has been significantly altered from its pre-20th century regime by dams, revetments, and levees in three primary ways: (1) channel simplification and reduced dynamism, (2) lowering of channel-bed elevation, and (3) disconnection of the river channel from the floodplain (Alexander et al. 2012). Notably, channel meandering has been eliminated by revetments, cutoffs have significantly altered the energy in the system, secondary channels have been altered by dike systems, and floodplains have been constrained by levees. For example, Winkley (1977) concludes that the LMR was a stable system between Cairo, IL and Natchez, MS in the pre-cutoff period, whereas stage adjustments followed the cutoffs of 16 bendways between 1933-1942. Although the morphology of the LMR has been altered significantly, it is important to recognize that the LMR, unlike the Upper Mississippi River, the Ohio River, and the Missouri River, is not heavily controlled by main channel dams and flow regulation (Biedenharn & Watson 1997; Soar et al. 2005). Therefore, the LMR is still a dynamic, open river system where morphologic adjustments are still occurring, albeit, within the constraints of a river controlled for flood risk management and navigation. Therefore, the impacts to habitat should be viewed within the context of an altered, but still dynamic river system.

Hydrology and Hydraulics

One distinct feature of the LMRV is the formation of natural levees along the banks of rivers and the associated backwater deposits dominated by dense alluvial clays that historically supported extensive wetland areas. The banks of the river can be as much as 10 to 15 feet higher than the lowlands farther back from the river. Because of these natural levees, drainage within the floodplain, frequently flows away from the Mississippi River to lower elevations near the valley walls, except near tributary confluences. Bottomland drainage is provided by streams running parallel to the river and joining it through major tributaries or at points where the river meandered close to the valley wall. The clays that formed these features have low permeability and limit the ability of rainwater to infiltrate the ground surface (Kleiss et al. 2000).

In the river proper, mean top bank width is 5,450 ft, while mean width of the low-water (3 percentile flow of the discharge, Q) channel is 2,960 ft (Tuttle & Pinner 1982). Water velocities vary widely but can exceed 10 ft/s around dike fields. The LMR hydrograph is variable, with yearly stage fluctuations of 20-40 ft (mean=22 ft). The river shows two distinct depth-distribution patterns (Miranda & Killgore 2013). Over its lowermost 248-mi segment, the river has been engineered to maintain deep water to support navigation of large container vessels, with a mean maximum depth near 66 ft and a maximum mean depth near 131 ft LWRP. The Low Water Reference Plane (LWRP) is associated with the discharge that is equaled or exceeded 97% of the time taken from flow duration curves. This deep segment is a relatively

homogeneous navigation channel, with limited variability in depths (Coefficient of Variation, CV, 40-60). Above river mile 248, mean maximum depth at LWRP is near 26 feet and maximum depth can exceed 100 ft below LWRP. Variability in depths in this upper segment of the river is higher than in the first 250 mi (CVs about 50-70). April has the highest average monthly discharge (947,457 cfs), and October has the lowest average monthly *Q* (260,844 cfs) (Tuttle & Pinner 1982). At Vicksburg, MS, (rm 437) mean *Q* is 617,000 cfs for the 1944-1994 period and mean suspended sediment load is 198 x 10^6 tons/yr (Moody & Meade 1992). Maximum discharge at Vicksburg, MS during the height of the 2011 flood was 2,272,000 cfs (MR&T 2012). The timing, duration, and frequency of annual low-discharge and high-discharge events, however, vary widely among years.

Although the stability of the LMR reflects the contribution of a variety of factors such as levees, cutoffs, dikes, revetments, and dredging, the event that has had the most pronounced morphological impact on the LMR was the meander cutoff program of the 1930s and 1940s. Biedenharn & Watson (1997) documented the stage adjustments in the LMR during the pre-cut-off (1880s–1930s), and post-cut-off (1943–1994) periods and found that the entire Mississippi River, between Natchez, MS, and Cairo, IL, is responding in a manner similar to the response of a stream to a single cut-off. Their study identified a degradational regime between Sunflower, MS, and Fulton, TN, and an aggradational regime between Vicksburg and Natchez, MS. Upstream of Fulton and the reach between Sunflower and Vicksburg were transitioning to dynamic equilibrium. It should be recognized that these are long-term decadal trends and that short-term reversal of trends, usually in response to major flood events, may occur. Although these may be slow, long-term trends, their impact on habitat may be significant, due to changes in the hydrologic connectivity between the secondary channels and floodplain. This is particularly an issue in the degradational reaches of the river where the stage duration changes may cause the diked secondary channels to become more hydrologically isolated from the river. The evolutionary trends on the LMR occur over long time periods, and are typically measured in multiples of decades. Therefore, an opportunity exists to develop management strategies to mitigate the impacts of these long term trends.

Habitat Classification and Distribution

There have been several aquatic habitat classifications of the LMR. The river is divided into the channel and floodplain, and within each of these two broad categories, macrohabitats have been defined based on geomorphic, hydraulic, biological, and other descriptors (Baker et al. 1991). More recently, nine macrohabitats were defined in Table II-1 for the channel environment that can be easily identified and mapped (Miranda & Killgore 2011). Channel and sandbar habitats are most common in the LMR, revetted banks [Articulated Concrete Mattresses (ACM)] occur along outside bends, and natural banks occur along inside bends associated with vegetated islands, most secondary channels, and abandoned bendways. There are over 100 island complexes, which include a secondary channel, island usually vegetated, and main channel border (Williams & Clouse 2003). A more recent study identified 199 chutes, which include both vegetated islands identified by Williams and Clouse (2003), and non-vegetated islands where flow in the main channel zone is bifurcated by a point bar or mid-channel bar bed forms with a crest elevation $\geq$ +5 ft. LWRP (Guntren et al. 2012). Dike fields are dispersed throughout the channel border down to the lower reaches near Baton Rouge, LA (rm 212 to 953.5) and average 1.0 dike/rm. Of the 774 dikes constructed since the beginning of the dike construction

effort on the LMR, 225 (29%) have been notched. Overall, there are about 482,418 acres of aquatic habitat within the top banks of the river, assuming a bank-full stage (MR&T 2012).

Table II-1. Type and abundance of macrohabitats in the Lower Mississippi River.

Habitat type	Description	Abundance
Steep sandbar	High sloping sandbar often associated with the downstream reach of an island or point bar where the maximum current speeds begin to cross the channel forming eddies, deep water, and depositional areas along the bank.	8,649 acres[1]
Gentle sandbar	Low sloping sandbar with moderate to high current. They constitute the primary littoral habitat in the river and occur in association with point bars, islands, middle bars, and dike systems	70,425 acres[2]
Island complex	Usually include, from the bank outward, a secondary channel, island, and main channel. Upper reach is shallow and swift while lower reaches become deeper and sluggish.	25,652 acres at 0 LWRP; 93->100 side channels[3]
ACM/riprap	Articulated Concrete Mattress (ACM) is placed over eroding river banks with riprap along the top portion. Buckling and variation in bottom slopes create large interstitial spaces surrounded by hard substrates. Strong currents and deep water are usually associated with this habitat.	17,915 acres[4]
Natural bank	Usually occur on the concave side of the river where consolidated silts and clays form the primary substrate. Banks are often steep and woody debris from fallen trees can accumulate.	9,266 acres [4]
Flooded shoreline	At high stages, flooded sandbars and willow trees provide temporary habitats usually occurring along the convex side of the river. Detritus and terrestrial vegetation become available in relatively shallow, low velocity refugia.	More than 360 mi at overbank flows[5]
Gravel bar	Coarse sand and gravel are deposited in bendways usually in the upper reaches of point bars or islands where water is shallow and swift. Gravel may extend from the shoreline to the channel border.	At least 76 bars with predominately gravel[6]
Channel	Includes the main channel and channel border. Water depth can exceed 25 m, currents are strong, and substrate is usually sand.	321,237 acres [4]
Dike	Constructed with large rocks and extend perpendicularly from the bank to the channel border habitat. Some dikes can exceed 900 m in length. Large eddies can form below dikes, and depth and velocity varies greatly along its longitudinal axis.	Avg. of 1.0 dikes/RM[7]

[1] Analogous to lentic sandbars from Baker et al. (1991)
[2] Analogous to lotic sandbars from Baker et al. (1991)
[3] Williams and Clouse (2003)
[4] Baker et al. (1991)
[5] Derived by dividing the river length between the Ohio River and Baton Rouge by 2 (720 mi/2=360) to represent a minimum value for the convex side of the river, which would always be less than the concave side but more than 360 miles.
[6] See Table II-2
[7] Based on 774 dikes constructed up to 2012 on the LMR between river miles 212 to 953.5.

Gravel bar habitats are of particular interest in the Conservation Plan because of their importance as spawning substrate for pallid sturgeon as well as other fish species. A recent study conducted by ERDC-GSL and the Biedenharn Group identified the general location of gravel deposits in the Lower Mississippi River using historical Red Hen imagery, photographs, field observations, and historical potamology data. The Red Hen System allows for geo-referenced HD videos to be acquired from the helicopter reconnaissance. With this technology,

geo-referenced videos provide latitude and longitude in a continuous fashion along the entire flight route, thereby allowing the investigator to accurately locate all pertinent features along the stream. This results in a more efficient use of resources, and provides a broader perspective at a significantly reduced cost. This analysis divided 138 channel bars between Cairo, IL, and Old River into four broad categories as shown in Table II-2. Although the amount of gravel generally decreased in the downstream direction, it is significant that gravel was observed throughout the study reach. This analysis represented a major first step with respect to identifying gravel locations along the river. However, these results are considered preliminary for the following reasons:

- The resolution of the Red Hen videos was often inadequate to definitively identify the presence of a gravel bar.
- Gravel deposits may have been under water at the time of the Red Hen flights. The recent 2012 Red Hen flight that was conducted at extreme low water following the 2011 flood, has not been analyzed yet, but preliminary indications are that gravel bars may have been more prevalent than in previous flights.
- It is also likely that many gravel deposits may have been covered by sand at the time of the Red Hen flights. In fact, analysis of the historical potamology data have indicated that these are highly dynamic features, with gravel bars being alternately buried in sand and then exposed again through time.
- At some locations where gravel was observed, it is possible that these were armor layers rather than extensive gravel bars.

Table II-2. Classification of channel bars between Cairo IL and Old River.

Classification	Number Observed
GS – Predominately Gravel	44
SG – Predominately sand but with considerable gravel	32
SPG –Mostly sand, with possible gravel, but not definitive	49
S – Predominately sand with little to no gravel	13

The LMR leveed floodplain, which includes the floodplain contained between the levees (i.e., the batture) and backwater areas, is a dynamic freshwater ecosystem, often changing markedly in response to the river's annual hydrologic regime. The 2.25 million-acre leveed floodplain is interspersed with abandoned channels (e.g., oxbow lakes), meander scars (e.g., sloughs), levee borrow pits, and large expanses of forested wetlands, and tributary mouths (Baker et al. 1991). These areas provide a diverse array of aquatic habitat types and are connected to the river at high water. Based on MR&T (2012), the LMR floodplain lying riverward of the levees is comprised of about 2.25 million acres and varies in width from 1 to 15 miles. The land cover in 1992 consisted of about 1,313,090 acres of forests, 371,569 acres of agricultural lands, and 127,408 acres of lakes, streams, and man-made water bodies (Table II-3). These lands function as the main overflow system of the river and contain a diversity of terrestrial habitats and bottomland hardwood forests. Sugarberry/American elm/green ash, sycamore/sweetgum/ American elm, black willow and cottonwood/willow forest types make up 70% of the wooded bottomlands.

Baker et al. (1991) noted a number of distinct changes in the river ecosystem compared to the historic unaltered system. The overall floodplain was reduced by 80% due to the levee system. Many oxbow lakes are now outside of the levee system, and other waterbodies within

the batture gradually fill due to sediment accretion. Turbidity, sedimentation, and expanded agricultural development impact aquatic communities associated with oxbow lakes in the Mississippi Alluvial Valley (Miranda & Lucas 2004). Main stem habitats have been altered as well. Channel cut-offs reduced the number of bendways, which shortened the river causing a major loss in channel habitat including pointbars and gravel bars. Dike fields reduce aquatic surface area due to sediment accretion between dikes, although dikes associated with outside bends often scour sediments and increase pool habitat. Closure dikes across the mouths of secondary channels increase sand deposition that reduces hydraulic connectivity to the main channel. Williams &Clouse (2003) reported a loss of 23 secondary channels with vegetated islands from the 1960's to the 1990's due to sedimentation in the channel, and Guntren et al. (2012) reported a similar trend for chutes (non-vegetated secondary channels) continuing into the 2000's. Natural steep banks have declined substantially due largely to the construction of revetments (Baker et al. 1991). However, channel habitat and transitional areas between the thalweg and shoreline (i.e., channel borders) have persisted over time and continues to provide habitat diversity in the mainstem LMR.

Table II-3. Distribution of Major Habitat Types Within the Lower Mississippi River Valley[1]

Habitat Type	Area (acres) [% total]
Bottom land hardwood forests	981,887 [35 %]
Agricultural Lands	478,345 [17 %]
Open Water (Lakes, borrow pits)	515,656 [18 %]
Backwater Areas (sloughs, ponds)	680,800 [24 %]
Other	137,186 [6 %]
Total	2,793, 874

[1] – Mississippi River and Tributaries 2011 Post-Flood Report, June 2012, Mississippi Valley Division

Effects of Climate Change on the Mississippi River System

The ability to predict the impacts of climate change on a river system as large as the Mississippi River is wrought with significant uncertainties. Ultimately, it would be desirable to integrate climate change studies and water resource evaluations to the point where one can predict changes in river discharges and attribute those changes to either climate variability or change. However, at this point in time, efforts remain rudimentary and integration of the multitude of driving variables that influence discharge for the Mississippi have not led to conclusive predictions of change. For instance, Caldwell et al. (2012) noted that increases in impervious cover by 2060 may offset the impact of climate change during the growing season in some watersheds, while in other areas, increased water withdrawals for human consumptions, industrial utilization and irrigation could either offset or exacerbate climate change impacts. Hirsch and Ryberg (2012) concluded that there was not strong statistical evidence relating historic flood magnitudes to changes in global mean CO_2 levels. Additionally, the Mississippi River basin has had significant annual and inter-annual variability throughout the period of historical record. As a recent example, between the flood of the spring of 2011 and the drought

of 2012, water levels at the gage in Memphis, Tennessee varied by 59 feet. Natural interannual and inter-decadal variability make it difficult to detect potential climate changes due to anthropogenic or other sources.

Despite these constraints, climate scientists have suggested a few trends for the watershed that may be useful to consider. Bonnin et al. (2011) presented evidence that there will be an increase in heavy, flood-inducing precipitation events, particularly in the Ohio Basin that would have a direct influence in the LMR. Raff et al. (2009) also found that for the James River in the Missouri River Basin climate projections result in an increased simulated annual maximum flood potential through time. Also, Kunkel et al. (2013) report that although there is also large interannual variability in regional temperatures, historical tendencies for the Midwest U.S. as a whole are towards increased annual temperatures. Trends calculated from temperature data show a 0.11˚F per decade increase in annual mean temperature over the Midwest during the 1900-2010 period. Another predicted outcome is increased or prolonged periods of drought (IPCC 2007; GCRP 2009) that may affect in channel habitats utilized by pallid sturgeon and other species that are their food items.

At this time, it is difficult to say whether any of these potential climate-induced changes are likely to have any measurable impact on the three species that are the subject of this report.

Part III: AUTHORIZED PROJECT DESCRIPTION

Channel Improvement Program

In response to the 1927 flood, the MR&T Project was authorized by the Flood risk management Act of 1928, which has been modified numerous times to provide the present project authority. The MR&T Project along the main stem of the Mississippi River includes an extensive, 2,216-mile levee system; three floodways to divert excess flows past critical reaches; and channel improvement and stabilization features to protect the integrity of flood reduction measures and to ensure proper alignment and depth of the navigation channel. The Channel Improvement Program of the MR&T project provides for a low-water navigation channel nine feet deep (authorized to 12 feet) and 300 feet wide from Baton Rouge, LA to Cairo, IL and for stabilization of river banks to protect the flood risk management levees from Head of Passes, LA to Cairo, IL and on the lower 9 miles of the Ohio River. This Conservation Plan applies to the Channel Improvement Program (CIP).

The CIP consists of the construction of river engineering structures, including stone dikes, foreshore protection dikes, articulated concrete mattress (ACM), and trench fill revetments; and maintenance dredging to maintain the channel depth and width in the main stem of the Mississippi River. Construction dredging has also been used in a few instances. As of September 2012, there were approximately 355 miles of stone dikes, 145 miles of foreshore dikes, and 1,055 miles of operative revetment on the LMR. Stone dike work is about 91 percent physically complete, with 35 miles of dikes remaining to be constructed. ACM revetment work is approximately 97 percent physically complete, with 36 miles to be built in the future. The CIP is scheduled to be finished in 2020. Continued maintenance beyond 2020 will be required.

River Engineering Structures

Three main types of river engineering structures are used in CIP: Revetments, dikes, and bendway weirs. In addition, hard points, roundpoints, and chevron dikes are used in some instances. A combination of these structures work synergistically in a river reach to achieve both flood risk management and navigation objectives. The effects of these structures on endangered species habitats are discussed in Part V.

Revetments

Revetments are placed on riverbanks to arrest bank caving and protect levees and other structures, and to maintain an efficient channel alignment. Caving banks of the LMR are typically stabilized with ACM. ACM is comprised of concrete blocks 46.5 inches long, 17.75 inches wide, and three inches thick spaced one inch apart and tied together with corrosion-resistant wire to form a continuous mattress.

In the 1980s, ACM design was modified for environmental enhancement. ACM is now constructed with longitudinal grooves over the surface of each block to reduce current velocity and increase surface area for the attachment of macroinvertebrates (Way et al. 1995). ACM is placed on the graded bank slope from just above the water surface at the time of construction and extended to a prescribed point in the channel not necessarily to the bottom. The upper bank area is graded to a typical slope of 1 vertical to 3 horizontal and paved with riprap stone; asphalt was

used prior to the early 1960's. ACM is flexible, strong, and durable and ensures complete coverage of the bank. About eight percent of the ACM surface is comprised of spaces between the individual blocks. Trench fill revetment is also occasionally used in the LMR for major channel realignment or when some continued erosion of the river bank is required to provide a desired channel alignment. A trench is excavated on the land or island along the design channel alignment and filled with quarry stone. When the river migrates laterally into the filled trench, the stone launches and stabilizes the bank.

Pokrefke (2012) described Off-Bankline revetments as an environmental enhancement alternative, providing slack water habitat compared to traditional On-Bankline revetments. According to Pokrefke (2012), the Off-Bankline revetment is a row of stone, typically "A" stone, and is placed 5 feet to 15 feet riverside of the existing bankline at an elevation of the existing bank height. Notches are typically left in the revetment to allow fish to access the slack water areas.

Between 2003 and 2012, linear feet of revetment placed averaged (± standard deviation) 48091.9 ± 9853.9 (Table III-1). The majority of revetment laid was to repair revetment damaged by floods. Annual variability was due to funding, magnitude of flood damage and length of low stages conducive for construction activities. As of 2012, there are 1055 miles of revetment along the banks in the LMR.

Table III-1. Linear feet of revetment laid over the past ten calendar years in the Lower Mississippi River.

District	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
	New									
Memphis	5554	6077	1893	5829	3552	5305	2276	1392	0[1]	0
Vicksburg	6105	9159	12855	6610	9726	6669	7374	9581	0	1950
New Orleans	0	0	0	0	0	0	0	0	0	0
	Maintenance									
Memphis	14983	14667	14350	12793	13952	9192	17020	13071	0[1]	34218[2]
Vicksburg	6802	9196	9984	7315	11132	10002	8502	10094	6512	27468
New Orleans[3]	10401	12057	8361	26818	11175	12370	15248	10688	7849	n/a
Total	43845	51156	47443	59365	49537	43538	50420	44826	14361	63636

[1] – No ACM placed due to flood
[2] – All flood-damaged ACM
[3] – Combined maintenance and reinforcement

Dikes

Dikes have been used intermittently on the Mississippi River for over a hundred years; however, beginning in the 1960s, a comprehensive dike program was initiated in an effort to reduce dredging costs, and establish improved navigation alignments. Stone dikes are constructed in the river channel to develop a self-maintaining (minimal maintenance dredging), low-water navigation channel with authorized project dimensions and alignment. Dike systems function, in conjunction with revetments, to modify and stabilize channel alignment, reduce discharge through secondary channels, and decrease width and increase depth of the low-water (navigation) channel through bed degradation, mainly in channel crossings (Fenwick 1969; Cobb & Magoun 1985).

The morphological response to the construction of dikes is site specific and depends upon a number of factors such as dike type (permeable or impermeable), dike elevation, configuration (level crest, sloping crest, and stepped up or stepped down), dike angle and length, local channel sediment characteristics (size and concentration), and the hydraulic and hydrologic characteristics of the channel. However, there are some general trends associated with dikes that typically occur. First it should be recognized that the hydraulic effects of dikes will vary with stage. The top elevation of a dike is often designed well below the top bank elevation to minimize impacts of dike construction at higher flows. Secondly, it must be recognized that the hydraulic and sedimentation impacts of dikes also change with time. When first constructed, the cross-sectional area of the channel will be reduced due to the presence of the dikes. However, this reduction in area is insignificant at high water stages. With time, the dikes will typically induce sediment deposition in the area between the dikes, and increase the area and depth in the main channel due to erosion.

Design of stone dike systems is variable and depends on purpose, site conditions, and economics (Pokrefke 2012). Spacing of dikes is based on experience and local factors, but is typically one to two times the length of the next upstream dike. Dikes comprising a system may be stepped-up, i.e., dike crown elevations increase downriver, or stepped down, i.e., dike elevations decrease downriver. Stepped-down dike systems tend to increase deposition between dikes during high discharges which successively overtop each dike as stages rise, while stepped-up systems tend to promote scour between successive dikes (Franco 1967; Fenwick 1969). However, studies of dike systems on the LMR have shown that sedimentation was higher in level and stepped-up systems than in stepped-down systems. This may be due to the large channel width and wide spacing of dikes.

Transverse stone dikes, also called spur dikes, are linear structures that range in length from 1,000 to 12,000 feet (mean = 2,000 ft.) and are built of large quarry-run stone. They extend from the bank into the channel and are oriented perpendicular to flow or are angled as much as 30 degrees downstream or upstream, depending on local conditions and objectives. Stone dikes are trapezoidal in cross-section, generally with a crown width of 5-14 ft and a longitudinal profile that slopes from the riverbank towards the channel. A sloped dike profile enables the structure to affect channel alignment over a range of low to mid-bank stages. Dike length is based on total channel width and the design width or trace of the navigation channel, i.e., the required amount of channel contraction and conveyance. Crown elevations are based on the degree of channel control required, existing bed elevations, and costs. For example, a dike that traverses a deep secondary channel may have a relatively low crown elevation because construction cost increases exponentially as a function of dike height. A trail or L-head section may be constructed at a right angle and extend downstream from the channelward tip of a transverse dike to increase channel control at reduced cost or to simulate bank alignment. Rootless dikes are also used to provide habitat diversity. This type of dike has an offset typically 100 feet or more from the river bank (Pokrefke 2012). The rootless section provides environmental diversity by altering flow and sediment transportation, and multiple dikes can be left rootless and in a line to create a secondary channel for environmental enhancement (Pokrefke 2012).

As a result of the MR&T dike program, dredging costs on the LMR have been reduced dramatically. However, the associated deposition of sediment within the dike fields reduces

aquatic surface area, degrading the quality of these valuable aquatic habitat areas. In response to these concerns, a detailed data collection program was established by the Mississippi Valley Division (MVD) in order to quantify the sedimentation trends in these dike fields. Utilizing these data, Biedenharn et al. (2000) conducted a detailed study of the sedimentation trends of 28 individual dike fields on the Lower Mississippi River. For this study, the channel was divided into three distinct areas (main channel, pools, and sandbars) based on the classification scheme developed by Cobb and Magoun (1985). The pools are basically the area between the dikes as defined by the area circumscribed by the bank line and a line connecting the channel-ward tips of the dikes. The sandbar areas were defined as the bar area between the pool boundary and the -10 foot Low Water Reference Plane (LWRP) contour. The boundary of the main channel is the remainder of the channel up to the -10 foot LWRP contour. Although there was considerable uncertainty and variability in the individual dike-field trends, some general trends were observed. According to their report:

- The largest impacts of the dikes occur in the initial response period (first 5 to 15 years following dike construction) after which the response decreases significantly.
- The pool (area between the dikes) response is dominated by decreases in surface area, volume, and depth. However, these filling trends are affected by a number of factors. The filling trends are most pronounced in the tighter bends (Radius of Curvature/Width < 5), with the impacts being lessened as the bend radius increases. Filling is also the dominant process in the straight reaches, but the trends are less consistent, with a number of reaches actually exhibiting enlargement. The most significant filling appears to occur in the initial 5 to 10 years following dike construction. These filling trends continue through time, but at a reduced rate.
- The main channel response was dominated by increases in surface area, volume, and depth. The most significant enlargement of the main channel occurs during the initial period immediately following dike construction.
- The sandbar area (identified as a transition area between the main channel and the pools) was highly variable, experiencing both scour and fill. The sandbars appear to represent a transition zone between the filling trends in the pools and the scouring trends in the main channels.
- The volume trends for the overall reaches (combined main channel, pools, and sandbars) indicate that the overall reaches have either enlarged or experienced no significant change, while the surface area showed no significant change or minor decreases. Thus, it appears that the dikes have either produced a larger, more efficient channel, or had no significant impact on the overall channel cross section at all.

In recognition of the potential loss of habitat resulting from sedimentation in the dike fields, the Corps began a dike notching program on the Lower Mississippi River in the late 1980s. A dike notch is a weir section in the dike that is designed to maintain flow through the dike fields at low river stages, thereby minimizing the adverse sedimentation impacts in the secondary channels. The size of the weir section depends on local site conditions, but typically the top width varies from about 100 to 300 feet, with a weir invert of about +5 feet above the LWRP. Not all dikes are subject to notching, either because of location and minimal

environmental benefits, or because a notch would reduce their integrity of purpose (e.g., short dikes).

Hubbard et al. (2006) conducted a limited analysis of pre and post notching surveys within the Memphis and Vicksburg Districts. This was not a comprehensive assessment of dike notching, but rather was a limited investigation based on five dike fields with a short post-notch time period ranging from 5 to 11 years. Because of the limited data, this study did not produce any conclusive trends that could be extrapolated to dike notching in general. However, the study did provide useful insight into the behavior of the five dike fields studied. Specifically, the study showed that the spatial and temporal scour and fill trends in the dike fields were extremely dynamic. The response to notching was observed to be site specific, with locations of scour and fill varying from year to year within the dike fields. These findings are important because they document that the dike fields are not static environments, but rather are temporally and spatially highly dynamic systems.

A total of 774 dikes, averaging 1.0 dike/rm, have been constructed between river miles 212 to 953.5 since the beginning of the dike construction effort on the LMR (Table III-2). Of the 774 dikes constructed, 225 (29%) have been notched to diversify bathymetry below the dike. Notching closing dikes of secondary channels may be most effective in diversifying habitat conditions by maintaining flows in secondary channels for extended periods during low river stages. To date, the combined efforts with LMRCC have cost-efficiently rehabilitated nine secondary channels with notched dikes, totaling almost 40 miles of in-channel habitat and enhanced hundreds of acres of seasonally flooded habitats, and without impacting the COE's primary missions of flood damage reduction and provision of a safe, stable commercial navigation channel.

Table III-2. List of river training structures, excluding revetment, constructed up to 2012 or proposed for the Lower Mississippi River.

River Training Structure	Memphis District	Vicksburg District	New Orleans District	Total
Total Dikes Constructed				
Dikes	467	293	14[1]	774
Notched Dikes	147	78	0	225
Hardpoints	209	28	0	237
Chevrons	4	3	0	7
Bendway Weirs	6	2	0	8
Proposed for 5-year Plan				
Dikes	28	16	0	44
Notched Dikes	14	4	0	18
Hardpoints	20	0	0	20
Chevrons	0	0	0	0
Bendway Weirs	10-13	4-6	0	14-19

[1] – Dikes occur down to RM 212 in the New Orleans District

Bendway Weirs

Bendway weirs, originally designed by Derrick et al (1994), are linear stone structures, similar to transverse stone dikes, except for where they are placed in the channel. These structures are placed from the concave bank across the main or navigation channel. A series of weirs are constructed in a bend to form a functional system. These structures typically have elevations 20 feet or more below the LWRP, thereby allowing passage of navigation traffic, and are variously angled upstream depending on site conditions. Bendway weir systems are designed to increase uniformity of flow, to lower velocities, and to reduce shoaling in a bend. These effects are accomplished by widening the low-water channel and making it shallower, resulting in a more rectangular, as opposed to a triangular, channel cross-section. The number, length, elevation, angle, and spacing of bendway weirs are based on site conditions and physical model tests. Bendway weirs were first constructed by the St. Louis District, and are now used in the MMR and the LMR. As of 2012, Vicksburg and Memphis Districts have constructed a total of 8 bendway weirs in the LMR (Table III-2).

Hardpoints

Hardpoints were designed to stabilize river banks as a cost-effective alternative to revetment. Hardpoints consist of stone fills spaced along an eroding bank line, protruding only short distances into the channel. Based on a description by Lagasse et al. (2009), a root section extends landward to preclude flanking. Hardpoints are most effective along straight or relatively flat convex banks where the streamlines are parallel to the bank lines and velocities are not greater than 10 ft/s within 50 ft of the bank line. Hardpoints may be appropriate for use in long, straight reaches where bank erosion occurs mainly from a wandering thalweg at lower flow rates. They would not be effective in halting or reversing bank erosion in a meander bend unless they were closely spaced, in which case spurs, retarder structures, or bank revetment would probably cost less. Hardpoints are most commonly placed in lieu of revetment along the concave bank in secondary channels in the LMR. Compared to revetment, hardpoints conserve natural river bank, diversify riverine habitat through deposition and scour, and provide velocity refugia for aquatic organisms. As of 2012, Vicksburg and Memphis Districts have constructed a total of 237 hardpoints in the LMR (Table III-2).

Roundpoints

Multiple Roundpoint Structures (MRS) are alternating rows of rock mounds within the footprint of a typical dike. According to Pokrefke (2012), this structure is built to a two-thirds bankfull stage with the spacing of the rock mounds a function of the structure height. MRS are used like a dike to maintain the navigation channel and to create flow and bathymetric diversity within a dike field; therefore, the main benefit of these structures is to create diverse flow and scour patterns for aquatic improvement (Pokrefke 2012).

Chevrons

Chevrons were originally used by the St. Louis District in the Middle Mississippi River as a river training structure for erosion control at the upstream end of islands and habitat restoration tool (Davinroy 1996). Only a few chevrons have been built in the LMR. Chevrons are typically used in wider reaches of the river where a flow split is desired. A C-shape rock dike is

constructed and aligned to split flow while protecting the existing shoreline. A series of chevrons are usually required to obtain the desired effect. The split flow scours the substrate along the outside trailing edges of the chevron. Scour also occurs within the interior of the chevron and can form small islands immediately downstream as sand deposits in more slackwater areas. Chevrons can simultaneously assist or aid bank protection, channel scour, and habitat diversity. As of 2012, Vicksburg and Memphis Districts have constructed a total of 7 chevrons in the LMR (Table III-2).

Dredging

One of the primary missions of the USACE is to maintain channel depth and width for commercial navigation. Between Cairo, IL and Baton Rouge, LA in the LMR, the USACE maintains a 9-foot deep channel (12 foot authorized) that is 300-feet wide and a 9-foot deep channel in the ports and harbors. Dredging occurs mostly at crossings (i.e., where the main current crosses from one bank to the other), of which there are approximately 200 between the mouth of the Ohio and Baton Rouge, LA (Baker et al. 1991). However, only a few of the 200 crossings are regularly dredged. Dredging can be substantial below Baton Rouge at low river stages to maintain the deep draft 45-foot channel, however this work is not done under the MT&T authority. Dredged material from the LMR is usually deposited directly in flowing water where it disperses throughout the channel or in existing dike fields. This method is referred to as within-banks or flow-lane disposal and is used above and below Baton Rouge. This type of disposal also has environmental benefits by maintaining sediment within the channel to build sandbars, reduce erosion, and provide material to build or replenish island habitats and coastal wetlands. In some cases, dredge material is pumped through a pipeline to nearby fields or other off-channel locations to build landforms, although this type of disposal has not been used in many years.

Different types of dredges (cutterhead, dustpan, and hopper) are used depending upon the area. In the LMR, large dustpan dredges (e.g., *Jadwin, Hurley, and Potter*) are most commonly used by the USACE. The suction head, approximately the width of the dredge, is lowered to the face of the material to be removed. High velocity water jets loosen the material which is then drawn by pump as slurry through the dredge pipe and floating pipeline where the material is deposited outside of the navigation channel. Hopper dredges (e.g., *Wheeler, Essayons,, and McFarland*) are typically operated where dredged material must be moved greater distances. Hopper dredges stores dredged material onboard and transport it to an approved disposal site. Hopper dredges are only used below Baton Rouge to maintain the 45-foot navigation channel. Cutterhead dredges (e.g., *Thompson*) are equipped with a rotating cutter apparatus surrounding the intake end of the suction pipe. Cutterheads can efficiently dig and pump up to a mile all types of alluvial materials and compacted deposits, such as clay and hardpan. Using booster pumps, cutterhead dredges have the capability of pumping dredged material longer distances, but can be cost-prohibitive and limited by available lengths of discharge pipe.

Over the past ten years, a total of almost 431,000,000 cubic yards of sediment have been dredged from the main channel of the Mississippi River, including the deep draft channel below Baton Rouge (Table III-3). This represents an average of 43,000,000 ± 12,000,000 cubic yards dredged each year. Annual variation in dredging amounts is due to river stage; low water years require more dredging to maintain the navigation channel. From 1948 - 2008, the total linear feet of dikes constructed has drastically reduced the amount of annual dredging required to

maintain minimum depth of the navigation channel, excluding the deep draft channel below Baton Rouge (Figure III-1).

Table III-3. Cubic yards of maintenance channel dredging, excluding harbors, over the past ten years in the Lower Mississippi River.

Year	Memphis District	Vicksburg District	New Orleans District				Grand Total
			Baton Rouge to Old River	New Orleans to Baton Rogue	Gulf of Mexico to New Orleans	New Orleans District Total	
2003	6,073,352	1,030,475	623,692	13,728,125	9,381,050	23,732,867	30,836,694
2004	4,953,282	1,422,200	452,464	8,656,512	13,010,523	22,119,499	28,494,981
2005	10,838,046	982,968	824,628	19,368,940	13,616,139	33,809,707	45,630,721
2006	5,883,104	3,102,696	441,035	9,953,606	7,245,234	17,639,875	26,625,675
2007	7,504,241	4,260,200	623,878	11,762,086	10,556,543	22,942,507	34,706,948
2008	5,814,028	1,851,804	325,695	28,773,375	13,406,342	42,505,412	50,171,244
2009	7,116,535	860,587	579,040	26,661,826	18,477,845	45,718,711	53,695,833
2010	7,126,552	1,318,424	366,180	22,994,560	23,055,732	46,416,472	54,861,448
2011	7,001,328	1,315,100	814,478	21,826,412	14,431,080	37,071,970	45,388,398
2012	12,706,518	3,323,993	1,926,194	24,523,153	17,626,336	44,075,683	60,106,194

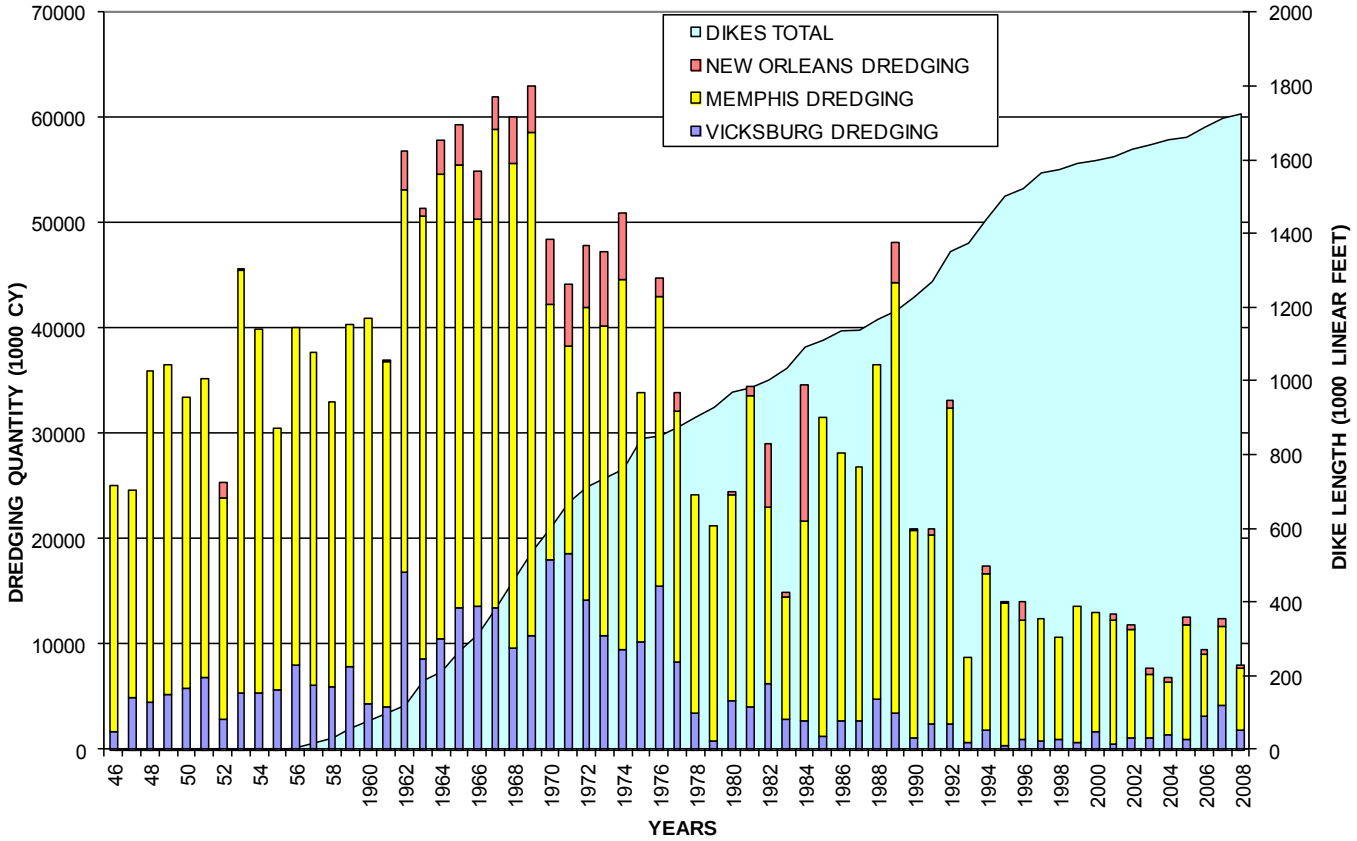

Figure III-1. Relationship between cumulative dike lengths and dredged quantities in the Lower Mississippi River, upstream of Baton Rouge and the deep draft channel and excluding harbors. Figure developed by Mississippi Valley Division

PART IV: ENDANGERED SPECIES ACCOUNTS

Interior Least Tern

The life history of least terns (*Sternula antillarum*) has been described in great detail many times, and in many different environments (Hardy 1957; Massey 1974; Wolk 1974; USFWS 2003, 2005a) and synthesized during the exhaustive literature review associated with the Birds of North America account for this species (Thompson et al. 1997) (which includes, in detail, distribution, habitat, food habits, demographics, and other life-history characteristics). Additional life-history information, as well as a detailed accounting of the Endangered Species Act, Section 7 Consultation process as it related to the USACE (Omaha District) is detailed in the 2003 USFWS Biological Opinion for the operation of the Missouri River (USFWS 2003). Management challenges for least terns also have been described in great detail (USFWS 1985; 1990a; 2003; 2005a, b; 2006). Research and monitoring needs have been articulated several times in collaborative settings (Guilfoyle et al. 2004; Lott & Pashley 2006; Martin et al. 2009; Guilfoyle & Fischer 2012). Hundreds of research papers, technical reports, Master's theses, and PhD dissertations have been written on a huge variety of topics in locations and environmental contexts spanning the entire geographic range (see the bibliography link at http://leasttern.org). Also, population models have been applied in numerous contexts (Kirsch 1996; Akçakaya et al. 2003; National Research Council 2004; Lombard et al. 2010; Lott & Wiley 2012). These topics are discussed in more detail below.

Life History

Least terns are fish-eating birds that nest in open sandy areas and other bare ground areas along rivers and coasts. The population of least terns that nest on large rivers in the central United States is known as the Interior Least Tern (ILT) (Figure IV-1). Sandbars are the primary habitat component used for ILT nesting. When sandbars become covered in vegetation, they are no longer suitable for tern nesting. New habitat is formed when high water removes existing vegetation or deposits new sand, or when sand is deposited properly during the dredged-material disposal process to create sandbars.

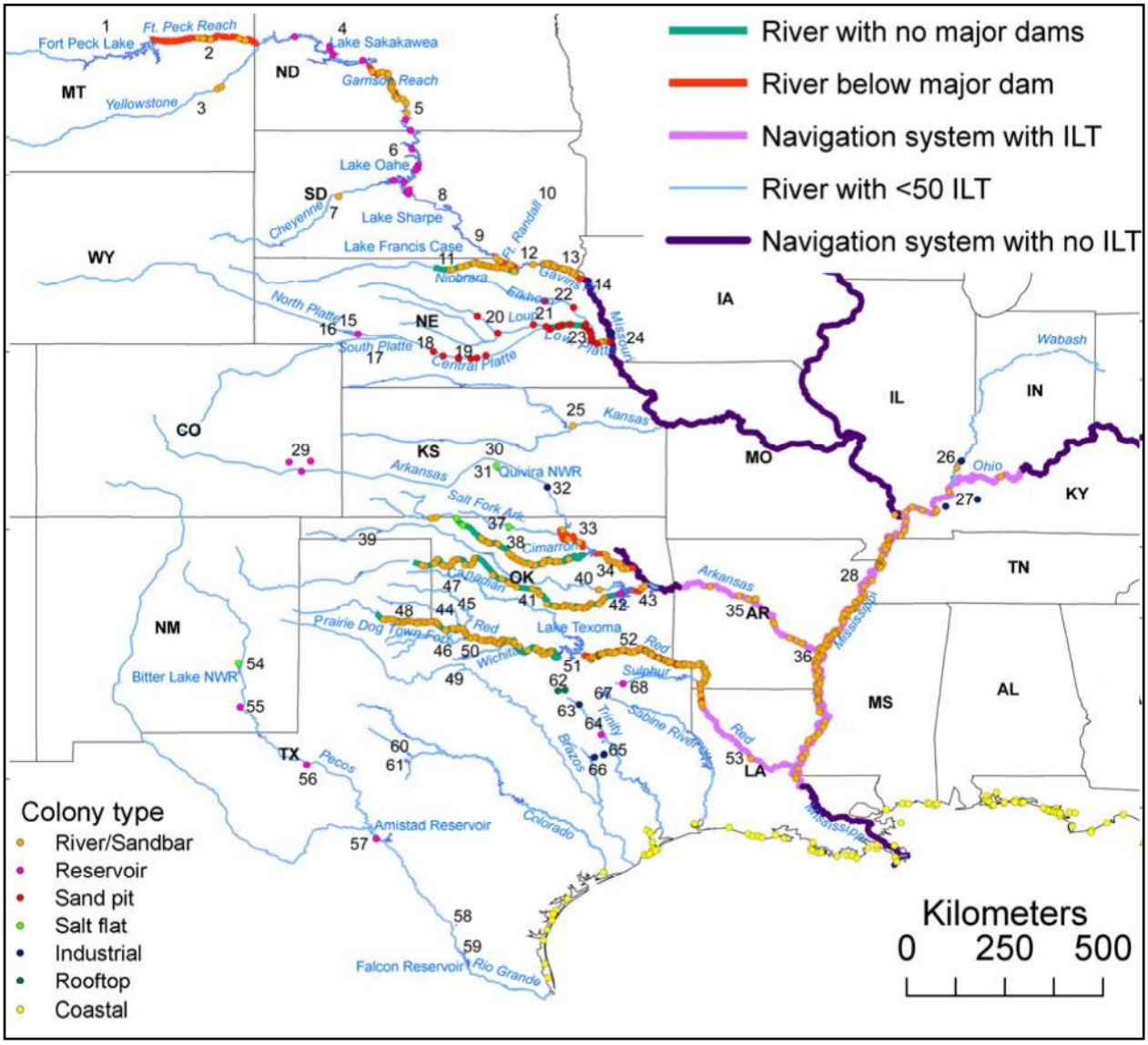

Figure IV-1. 2005 breeding distribution of the Interior Least Tern (ILT). See legends for colony types and river types. Numbers correspond to geographic segment numbers (From Lott 2006).

The ILT is found from the LMR, north to Montana along the Missouri River. The largest breeding populations occur on the LMR; along large Southern Great Plains rivers, particularly from the Arkansas, Cimarron, Canadian, and Red rivers; southern portions of the Upper Missouri River and its tributaries – the Platte and Niobrara Rivers; and in Illinois, Kentucky and Indiana along the Wabash and Ohio Rivers.

The interior population is one of two geographically-defined populations of least tern listed under the U.S. Endangered Species Act (ESA) as Federally endangered (the other being the California Least Tern). The interior population was Federally listed as endangered in 1985 because of suspected low numbers and concerns about breeding season habitat loss and degradation on large rivers of interior North America (USFWS 1990a). A recovery plan for ILT was published in 1990 that provided a summary of the known population size, identified suspected threats, and detailed delisting criteria (USFWS 1990a). This plan also outlined recovery strategies to increase the ILT population to approximately 7,000 adults

throughout its range, and to maintain drainage basin-specific target populations for 10 years (Table 1). This number was quickly reached, possibly due to more intensive surveys, improved survey techniques, and a better understanding of tern colony locations, especially on the LMR (Kirsch & Sidle 1999). However, concern has persisted about population size goals for other drainages as set in the recovery plan, as well as chronic threats to ILT (see below). The USFWS is currently conducting an assessment of the current status of the ILT (5-year review).

Distribution

Little is known about the historical distribution and abundance of ILT breeding along interior U.S. rivers. Least terns exploit early-successional habitats along rivers for breeding, nesting, and brood-rearing, and then migrate long distances to winter mostly outside of the United States. The dynamic nature of rivers, which may flood during the nesting season one year, and experience drought the next, provide a highly variable set of nesting conditions for terns upon return from wintering grounds. This environmental variability necessitated that terns develop life-history strategies to cope with such stochasticity. These strategies include their relative longevity (with total lifespans as long as long as 20 years), reproductive life-spans ranging from age 2 or 3 to death (Thompson 1982, Thompson et al. 1997), their ability to re-nest after nest failure (which can increase recruitment following flooding and/or egg/chick predation), and a diet that can include a variety of fish species.

Today, there is much more extensive information regarding ILT distribution and abundance (Figure IV-1). A wide variety of Federal and state agencies, universities, and non-governmental organizations have all conducted a myriad of research and monitoring activities throughout the range that provides a much clearer range-wide picture, much more so than even 10-15 years ago. In addition, tools such as the Cornell Laboratory of Ornithology eBird (www.eBird.org) portal are providing new information on least tern distribution from throughout the range that otherwise has been unavailable.

As a species, the least tern has a broad breeding distribution, with nesting records in 37 different US states (Thompson et al. 1997, Pyle et al. 2001, Lott 2006, Marschalek 2010), along both coasts of Mexico and northern Central America (Howell & Webb 1995), and many islands throughout the Caribbean (Thompson et al. 1997, Bradley & Norton 2009). Least tern breeding populations are nearly continuously distributed (with a few exceptions) from the Missouri River in Montana south through the Mississippi Valley (and its large western tributaries) along the entire Gulf of Mexico coast, west to Belize and east to Florida, up the Atlantic Coast from Florida to Maine, and throughout the Caribbean. Aside from California, coastal Least Terns are not Federally listed under the ESA, although they are on several state lists of conservation concern (Thompson et al. 1997).

There are several ecological factors that likely have influenced the contemporary distribution and abundance of ILT. First, frequent flooding events, which either create habitat, or set back plant succession on sandbars (where the majority of nesting attempts take place), strongly influences ILT distribution (Sidle et al. 1992, Leslie et al. 2000). Second, ILT tend not to nest in proximity to tall vegetation (i.e., riparian forest) or other high features (USACE 2011a-Appendix B), or where channels become narrow (Jorgensen et al. 2012). Third, reduced availability of small fishes as forage throughout the breeding season may result in very low chick survival and render breeding habitat as poor quality. Fourth, changes to river systems both

above and below reservoirs due to dam construction have resulted in hydrologic and sediment delivery alterations that have fragmented habitat, and subsequently, ILT drainage populations. Finally, in some locations, engineering practices have influenced distribution and abundance in a positive manner. For example, dike fields created by the USACE along the LMR designed to trap sediments and facilitate a self-regulating navigation channel have created habitat conditions (large sand accumulations behind dikes) that support the largest ILT population (by an order of magnitude) within their range (Lott 2006). Other types of nesting areas that were not historically available to ILT have also been exploited by the bird, such as reservoir shorelines, industrial sites, and dredged material deposition islands (Boylan et al. 2004; USACE 2011a,b; Fischer 2012).

The most comprehensive review of ILT distribution and population size was prepared by Mr. Casey Lott, American Bird Conservancy (ABC) under contract with USACE. Lott (2006) organized and synthesized the results of the only synchronized range-wide survey of ILT to date. Most recently he has summarized changes in knowledge of the distribution during a range-wide ILT workshop in Alton, IL, April 2012. In brief, a 25-year data set strongly suggests ILT range expansion within and outside of areas occupied at the time of the 1985 listing; invasion and occupation of a number of types of anthropogenic habitats (i.e., reservoirs, rooftops, sand mines, industrial sites); and expansion of range-wide bird population estimates, from a low of ~2,000 at time of listing, to >17,500 in 2005 (Lott 2006). The synthesis also demonstrates that the ILT has met or exceeded range-wide numerical recovery criteria identified in the 1990 recovery plan (7,000 adult birds) for at least 18 years (1994-2012). ILT numbers essentially doubled from 1995 to the 2005 range-wide count (e.g., Lott 2006: 17,591 ILT range-wide).

Breeding and Nesting Habitat

Sandbars are the primary habitat component used for ILT nesting. Sandbars generally are not stable features of the natural river landscape, but are formed, enlarged, eroded, moved, or destroyed, depending on the dynamic forces of the river. New habitat is formed when high water removes existing vegetation or deposits new sand, or sand is deposited properly during the dredged-material disposal process to create sandbars. When sandbars become fully vegetated, birds will not select them for nesting (Thompson et al. 1997). Flooding can scour some vegetation from sandbars and convert them back to suitable nesting habitat, but, at multi-year scales, if perennial woody vegetation becomes well-established and high flows can no longer remove vegetation, sandbars succeed to forest and permanently lose habitat value (Friedman et al. 1998, Johnson 2000, Wiley & Lott 2012).

Throughout much of the ILT range, the USACE is responsible for maintaining river navigation through practices such as dredging, dike construction, dredged-material disposal, and variable dam discharge actions (Fischer et al. 2004, Guilfoyle et al. 2004). These actions can have varying positive or negative effects on sandbar nesting habitat. Stabilization of major rivers for navigation, hydropower, irrigation, and flood risk management has destroyed, in large part, the dynamic nature of natural river processes (Smith & Stucky 1988). Many of the natural sandbars within the ILT range are unsuitable for nesting because of vegetation encroachment, or because they are too low and subject to frequent inundation. On the three major lock and dam navigation systems within the ILT range (McClellan-Kerr Navigation System on the Arkansas River, the Lower Ohio River Navigation System, and the J. Bennett Johnston Navigation System on the Lower Red River), ILT nesting occurs most frequently where regular dredging to maintain

navigation depths results in dredged material disposal within dike-fields or confined disposal facilities (USACE 2005, 2011b) or on mid-channel dredged material sites. While vegetation is often removed from dike-field disposal sites in AR due to flooding or large inter-annual stage differences that inundate bare sand areas for months at a time, dredged material sites with less dynamic flow regimes require regular vegetation control to persist as functioning nesting sites (USACE 2011b).

ILT also have nested on a variety of intentionally restored mid-river sandbars (usually in response to regional habitat loss), such as those on the Platte, Missouri, and Canadian Rivers (Hill 1993, Plettner & Jenniges 1999, USACE 2011a- Appendix B, 2011b), and reproductive success has been highly variable on many of these sites (USACE 2011a- Appendix B, 2011b). On the Missouri River, the extremely long-duration floods of 1995-1997 created large amounts of bare sandbar nesting habitat, which quickly was degraded due to erosion and/or vegetation succession. Subsequently, sandbar construction below Gavins Point Dam began in 2004, leading to the creation of significant nesting areas for the regional ILT population. On the LMR, sand island ILT nesting habitat has been maintained by a natural flood hydrograph. While dike construction on the LMR was previously considered a potential threat to ILT (by increasing connectivity of islands to banks), higher elevations of the islands due to effects of the dikes has apparently benefitted the species. These benefits are being maintained and enhanced, where appropriate, by the USACE dike notching program.

Wintering

Though much is known about the life-history of least terns during the breeding season in North America, comparatively little is known about life-history, habitat, and threats during the non-breeding season when most individuals migrate to wintering areas outside of the United States. Least terns of unknown breeding populations are found during the winter along the Central American coast and the northern coast of South America from Venezuela to northeastern Brazil (USFWS 1990a).

Abundance

Since the initial listing of this species, knowledge and understanding of the range and population demographics of ILT has grown considerably. Increased monitoring efforts have revealed larger population numbers and a greater extent of overall distribution of this species than previously thought. In November 2005, ERDC-EL sponsored a regional workshop on monitoring programs for the ILT in Tulsa, Oklahoma. Discussions focused on: 1) defining goals and objectives for local, regional, and range-wide monitoring programs; 2) deciding what information to collect during monitoring programs; 3) standardizing data collection and analysis protocols among programs; 4) integrating local efforts into regional or range-wide approaches; and 5) evaluating the effects of management actions on ILT within the context of regional or range-wide recovery (Lott & Pashley 2006). Repeated efforts to standardize count protocol and data reporting since this meeting have mostly failed, although data reporting has increased in some areas. This failure has been driven, largely, by the need for individual monitoring programs to continue to supply data to local USFWS field offices in the format that was originally requested of them for Section 7 compliance. Since most ILT monitoring programs in Districts and/or drainage basins have evolved independently, in the absence of communication among programs, and without any incentive for collaboration, it has been difficult to encourage change

among disparate monitoring programs, who most often stick to their unique regional protocols to be in compliance with biological opinions.

Although many ILT counts were conducted prior to 2005, regular survey coverage was incomplete across the large breeding range of ILT, limiting the ability to assess the conservation status or trends for this population. Because of the large number of programs collecting independent data on ILT (at least 29, reviewed in Lott [2006]), the ERDC-EL and ABC took the initiative to coordinate a range-wide survey during the last two weeks of June in 2005. Over 140 participants contributed to this survey, and ABC/ERDC raised additional funds, from the Tulsa District, to ensure counts were conducted in areas that are not covered by annual monitoring programs (Lott 2006). The primary objectives of this survey were 1) to provide a minimum count of the number of adult ILT occurring in North America during the breeding season, 2) to document the range-wide distribution of nesting colonies, and 3) to describe the types of habitats that are being used for nesting. Survey crews covered ~4,700 river miles, 22 reservoirs, 62 sand pits, 12 industrial sites, 2 rooftop colonies, and over 16,000 acres of salt flats, counting a grand total of 17,591 ILT in association with 489 different colonies. Just over 62 percent of all adult ILT were counted on the LMR (10,960 birds on 770+ river miles). Four additional river systems accounted for 33.3% of the remaining ILT, with 11.6% on the Arkansas River system (including the Canadian and Cimarron Rivers and the Salt Fork of the Arkansas River), 10.4% on the Red River system, 6.9% on the Missouri River system, and 4.4% on the Platte River system. Lesser numbers of terns were counted on the Ohio River system (1.0%), the Trinity River system in Texas (1.0%), the Rio Grande/Pecos River system in New Mexico and Texas (0.8%), the Wabash River System (0.6%), two reservoirs in East Texas (0.3%), and the Kansas River system (0.3 percent). A majority of adult terns were counted on rivers (89.9%), with much smaller numbers at sand pits (3.6%), reservoirs (2.5%), salt flats (2.3%), industrial sites (1.4%), and rooftops (0.3%).

Within the LMR, the USACE initiated annual nesting season tern counts between Cape Girardeau, MO, and Greenville, MS, following the 1985 listing. The survey reach was extended downstream to Vicksburg, MS, in 1988, and to Baton Rouge, LA, in 2004. These counts have documented a persistent increase in the number of ILT known to utilize the LMR, from approximately 300 birds in 1985, to over 12,000 in 2011 (Jones 2011) (Figure IV-2).

After the 2005 range-wide survey ABC and ERDC developed a flexible on-line data entry system for ILT surveys and encouraged partners collecting information on ILT to contribute their data. This database became the standard data entry platform for the Tulsa District's monitoring program (covering a large portion of the range of ILT), and resulted in the reporting of enough ILT counts in different areas to increase the understanding of range-wide distribution and abundance of ILT, beyond what was learned during the 2005 range-wide survey.

The ILT range-wide numerical recovery criterion (7,000 birds) (USFWS 1990a) has been met or exceeded each of the past 18 years (1994–2012). Using range-wide seasonal count data of adult ILTs from 1984 (722 terns) to 1995 (8,859 terns), Kirsch and Sidle (1999) demonstrated achievement of the numerical recovery criterion, and a positive range-wide population growth trend. They noted, however, that most of the ILT increase had occurred on the LMR, observed that population increases were not supported by available fledgling success estimates, and hypothesized that ILT increases were possibly due to immigration surges from a more abundant Eastern Gulf Coast least tern population.

Range-wide ILT counts doubled between 1995 and 2005 (e.g., Lott 2006: 17,591 adult ILT range-wide), and the majority of birds continue to be reported from the LMR (Lott 2006; ~62% of the 2005 range-wide count occurred in the LMR). Counts now equal or exceed population estimates for least tern along the U.S. Gulf Coast (Lott 2006). Lott (2006) noted marked declines in Gulf Coast least tern populations in recent years, hypothesized a wider least tern metapopulation that includes Gulf Coast and ILT subpopulations, and the potential for significant immigration from the Gulf Coast inland due to high human disturbance along the coast and presence of better nesting conditions on the LMR. However, there are no data or observations directly supporting either the Kirsch and Sidle (1999) or Lott (2006) immigration hypotheses as a factor in the 20+ year increase in ILT counts, either in the LMR or range-wide. Recent studies, however, have shown high genetic connectivity among groups of ILT inhabiting different drainage basins, as well as between interior and coastal populations (Draheim et al. 2010).

LMR Recovery Status

The 1990 delisting recovery criteria for ILT specified protection and management of essential breeding habitats, a range-wide population of 7,000 birds, and population targets for five river drainages - Missouri, Mississippi, Arkansas, Red, and Rio Grande Rivers.

Habitat protection and management programs have been established across the ILT range over the past 20 years, primarily under section 7(a)(2) consultations. Current range-wide population estimates exceed 17,000 birds. USFWS is currently conducting a review of the recovery status of ILT.

Pallid Sturgeon

The pallid sturgeon (*Scaphirhynchus albus*) is a benthic, riverine fish that occupies the Mississippi River Basin, including the Mississippi River, Missouri River, and their major tributaries (i.e. Platte and Yellowstone Rivers), and the Mississippi's major distributary, the Atchafalaya River (USFWS 1990b). Pallid sturgeon (PS) belong to the family Acipenseridae (Actinopterygii: Acipenseriformes) and members of this order are often referred to as "living fossils" because of their prehistoric appearance and representation in the fossil record from the Cretaceous period of geological history (Hilton & Grande 2006). North American Acipenserids are represented in the fossil record from the pre-Pleistocene period (Hilton & Grande 2006). The PS was first described in 1905 by Forbes and Richardson as *Parascaphirhynchus albus*, but was later placed in the genus *Scaphirhynchus* (Forbes & Richardson 1905; Bailey & Cross 1954).

In 1990, the PS was listed as an endangered species under the Endangered Species Act of 1973 (USFWS 1990b). Its decline was attributed to several anthropogenic impacts, including habitat modification and commercial harvest of the fish (USFWS 1990b). More recent studies have added water contamination, entrainment, and hybridization to the list of impacts (Divers et al. 2009; USFWS 2009a; Blevins 2011; Schrey et al. 2011). A recovery plan, which listed recommendations and policy changes, was issued by the USFWS in 1993, and included a projected recovery date of 2040. The shovelnose sturgeon (*S. platorynchus*) is a sibling species to the PS and shares much of its range. The two species are morphologically similar, although the shovelnose sturgeon is more abundant than the PS (Kallemeyn 1983; Killgore et al. 2007a).

To further protect the PS, the shovelnose sturgeon was listed as a threatened species under the Similarity-of-Appearance Provisions of the Endangered Species Act in 2010 (USFWS 2010b). This listing bans the commercial harvest of shovelnose sturgeon in areas where PS are known to occur (USFWS 2010b).

Habitat

Pallid sturgeon occupy the benthos of large, turbid rivers in North America, particularly the main channel (Kallemeyn 1983). Much of the natural habitat throughout the range of PS has been altered by humans, and this is thought to have had a negative impact on this species (USFWS 1993). Habitats were once very diverse, and provided a variety of substrates and flow conditions (Baker et al. 1991; USFWS 1993). Extensive modification of the Missouri and Mississippi rivers over the last 100 years has drastically changed the form and function of the river (Baker et al. 1991; Prato 2003). Today, habitats are reduced and fragmented and much of the Mississippi River basin has been channelized to aid in navigation and flood risk management (Baker et al. 1991). The impact of habitat alteration on pallid sturgeon throughout its range is unknown, but recent studies have shown that in the un-impounded reaches, suitable habitat is available and a diverse aquatic community exists (USFWS 2007). River restoration plans in the Missouri and Mississippi rivers are currently in place, although it is unclear how much progress has been made (USFWS 2007).

PS are thought to occupy the sandy main channel in the Mississippi, Missouri, and Yellowstone Rivers most commonly, but they are also collected over gravel substrates (USFWS 1993; Bramblett & White 2001; Hurley et al. 2004; Garvey et al. 2009; Koch et al. 2012). Several studies have documented PS near islands and dikes, and these habitats are thought to provide a break in water velocity and an increased area of depositional substrates appropriate for foraging (Garvey et al. 2009; Koch et al. 2012). Increased use of side channel and main channel islands has been noted in spring, and it is hypothesized that these habitats may be used as refugia during periods of increased flow (Garvey et al. 2009; Koch et al. 2012). Recent telemetry monitoring of PS in the LMR indicate use of most channel habitats, including dikes, revetment, islands, secondary channels, etc. (Kroboth et al. 2013).

PS occur within a variety of flow regimes (Garvey et al. 2009). In their upper range, adult PS are collected in depths that vary between 2-48 ft with bottom water velocities ranging from 2 ft/s and 3 ft/s (USFWS 1993; Bramblett & White 2001; Gerrity 2005). PS in the LMR have been collected at depths greater than 65 ft with a mean value of 33 ft, and water velocities greater than 6 ft/s with a mean value of 2 ft/s (ERDC unpublished data, Kroboth et al. 2013). Turbidity is thought to be an important factor in habitat selection by PS, which have a tendency to occupy more turbid habitats than shovelnose sturgeon (Blevins 2011). In the LMR, pallid sturgeon have been collected in turbidities up to 340 NTU's with a mean value of 90 NTU's (ERDC unpublished data).

Movement

PS, like other sturgeon species is a migratory fish species moving upstream annually to spawn (Koch et al. 2012). Movements are thought to be triggered by increased water temperature and flow in spring months (Garvey et al. 2009; Blevins 2011). Garvey et al. (2009) suggested that PS remain sedentary, or remain in one area for much of the year, and then move either

upstream or downstream during spring. It is possible that because movement in large, swift rivers requires a great amount of energy, this relatively inactive period may be a means to conserve energy (Garvey et al. 2009). Most active periods of movement in the upper Missouri River (RPMA2) were between 20 March and 20 June (Bramblett & White 2001). In one study, individual fish traveled an average of 3.73 mi/day and one individual traveled over 9.94 mi/day (Garvey et al. 2009). PS in the Missouri River have been reported as traveling up to 5.90 mi/hour and 13.30 mi/day during active periods (Bramblett & White 2001). PS may undertake long-distance, multi-year upstream migrations or movements, based on recaptures of shovelnose sturgeon in the Missouri River that were originally tagged in the LMR. Upstream distances approaching 1245 mi have been recorded (ERDC unpublished data) and similar distances have been recorded for downstream movements (USFWS unpublished data, Kroboth et al. 2013).

Aggregations of PS have been reported in several locations in the middle Mississippi River, particularly around gravel bars, including one annual aggregation at the Chain of Rocks Dam, which is thought to be related to spawning activities (Garvey et al. 2009). Aggregations of PS in the lower 8.70 mi of the Yellowstone River are thought to be spawning areas for sturgeon from the Missouri River (Bramblett & White 2001). PS have been found to have active movement patterns during both the day and night, but move mostly during the day (Bramblett & White 2001).

Feeding

Sturgeon are benthic feeders and are well adapted morphologically (ventral positioning of the mouth, laterally compressed body) for the benthic lifestyle (USFWS 1993; Findels 1997). Adult PS are primarily piscivorous (but still consume invertebrates), and are thought to switch from feeding primarily on invertebrates to piscivory around age 5 or 6 (Kallemeyn 1983; Carlson et al. 1985; Hoover et al. 2007; Grohs et al. 2009). In a study of PS in the middle and lower Mississippi River, fish were a common dietary component and were represented primarily by Cyprinidae, Sciaenidae, and Clupeidae (Hoover et al. 2007). Other important dietary items for PS in the Mississippi River were larval hydropsychid caddisflies, mayflies, and true flies (Hydropsychidae (Insecta: Trichoptera), Ephemeridae (Insecta: Ephemeroptera), and Chironomidae (Insecta: Diptera)) (Hoover et al. 2007). PS diet varies depending on season and location, and these differences probably are related to prey availability (Hoover et al. 2007). In a Mississippi River dietary study, Trichoptera and Ephemeroptera were consumed in greater quantities in winter months in the lower Mississippi River, while the opposite trend was observed in the middle Mississippi River (Hoover et al. 2007). Hoover et al. (2007) also found that in both the middle and lower Mississippi River, dietary richness is greatest in winter months.

Spawning

Freshwater sturgeon travel upstream to spawn between the spring equinox and summer solstice, and it is possible that either a second spawn or an extended spawning period may occur in the fall in southern portions of the range (i.e., Mississippi River) (USFWS 2007; Wildhaber et al. 2007). These spawning migrations are thought to be triggered by several cues, including water temperature, water velocity, photoperiod, presence of a mate, and prey availability (Keenlyne 1997; DeLonay et al. 2007; DeLonay et al. 2009; Blevins 2011). Gamete development is completed during the upstream migration and sturgeon are thought to spawn near the apex of their migration (Bemis & Kynard 1997).

It is thought that female *Scaphirhynchus* spp. do not reach sexual maturity until ages 6-17 and spawn every 2-3 years and that males do not reach sexual maturity until ages 4-9 (Keenlyne & Jenkins 1993; Colombo et al. 2007; Stahl 2008; Divers et al. 2009). PS and shovelnose sturgeon at lower latitudes (e.g., lower Mississippi River) may begin spawning at an earlier age than those in upper portions of the range (e.g., Upper and Middle Mississippi and Missouri Rivers) because they are thought to have shorter lifespans and reach smaller sizes (George et al. 2012). Also, LMR PS may be more highly fecund than those in northern portions of their range (George et al. 2012). It is thought that PS, like shovelnose sturgeon spawn over gravel substrates, but spawning has never been observed in this species (USFWS 1993; DeLonay et al. 2007; DeLonay et al. 2009).

Early Life History

PS larval hatchlings are approximately ¼-inch in total length, and feed on yolk reserves and drift downstream with the river current for 11-17 days, until yolk reserves are depleted (Snyder 2002; Braaten et al. 2008; DeLonay et al. 2009). Length of drift and rate of yolk depletion are dependent on several factors, including water temperature, photoperiod, and water velocity (Snyder 2002; DeLonay et al. 2009). Larval drift is not completely understood and the impacts of artificial structures, as well as the role of eddies, are unknown (Kynard et al. 2007; Braaten et al. 2008). During drift, sturgeon repeat a "swim up and drift" pattern, in which they swim up in the water column from the bottom (<10 in) and then drift downstream (Kynard et al. 2002; Kynard et al. 2007). A hatchery series of shovelnose sturgeon from Louisiana (J. Dean, Natchitoches National Fish Hatchery, unpublished data) reports complete yolk sac absorption at days 8-9 post-hatch, which is several days sooner than shovelnose sturgeon from Gavins Point National Fish Hatchery in South Dakota, so there could be a latitudinal difference in yolk absorption and larval maturation rates throughout the range of PS (Snyder 2002). Exogenous feeding begins when yolk reserves are depleted and drifting has ceased, and timing can differ latitudinally (DeLonay et al. 2009). The switch from endogenous to exogenous feeding is known as the "critical period", because mortality is likely if sturgeon do not find adequate food (Kynard et al. 2002; DeLonay et al. 2009). PS begin exogenous feeding around 11-12 days post-hatch in upper portions of their range, but exogenous feeding was observed in fish as small as 0.70 inches TL in the lower Mississippi River (Harrison et al., unpublished data), which could be as young as 6-8 days post hatch based on unpublished age and growth data from Natchitoches National Fish Hatchery (Braaten et al. 2007). The diets of young of year and juvenile PS and shovelnose sturgeon in upper portions of their ranges are much like those of the adult shovelnose sturgeon, and are primarily composed of aquatic insects and other benthic macroinvertebrates (Braaten et al. 2007; Wanner et al. 2007; Grohs et al. 2009). Young of year and juvenile PS in the LMR feed primarily on Chironomidae over sand in channel habitats (Harrison et al. 2012, unpublished data

Kynard et al. (2002), found larval PS to be photopositive with little preference for substrate color, except for a slight preference for light substrates when exogenous feeding began. It is thought that PS become increasingly photonegative starting around day 11 post-hatch (Kynard et al. 2002). In this same laboratory study, larval sturgeon swam in open habitats, seeking no cover under rocks in the swimming tube, and aggregated in small groups around days 3-5 post-hatching (Kynard et al. 2002). The black tail phenotype of young sturgeon is thought to aid in recognition and aggregation (Kynard et al. 2002). PS have been observed swimming and drifting at a wide range (2-118 in) above the bottom depending on water velocities (although

most fish are thought to say in the lower 20 in of the water column), and drift velocities are thought to range from 1-2 ft/s (Kynard et al. 2002; Kynard et al. 2007; Braaten et al. 2008). Drift distance of larval sturgeon is thought to be between 86-329 mi (Kynard et al. 2007; Braaten et al. 2008). Juvenile PS have been found in water depths ranging an average of 8 ft in the upper Missouri River (Gerrity 2005). Maximum critical swimming speeds for juvenile PS range from 0.3 ft/s to 0.8 ft/s depending on size with larger juveniles (6-8 in TL) able to withstand higher water velocities than their smaller counterparts (5-6 in TL) (Adams et al. 1999).

Distribution and Abundance

PS occur in parts of the Mississippi River Basin, including the Mississippi River south of the Missouri River, and the Missouri, Atchafalaya, Yellowstone, and Platte rivers, where it is adapted to pre-modification habitats of these systems (Kallemeyn 1983; Killgore et al. 2007a). Recovery efforts have divided the extensive range of PS into four management units (Figure IV-3a) [previously six recovery priority management areas (RPMAs) (Figure IV-3b)] (USFWS 1993 & 2013). These areas were selected as areas of high importance for recovery task implementation based on population variation (i.e., morphological, genetic) and habitat differences (i.e., physiographic regions, impounded, unimpounded reaches) throughout the extensive range of the PS (USFWS 1993). The Great Plains Management Unit (GPMU) extends from Great Falls of the Missouri River, Montana, to Fort Randall Dam, South Dakota, and includes the major tributaries thereof (Yellowstone, Marias, Milk Rivers). The Central Lowlands Management Unit (CLMU) includes the Missouri River from Fort Randall Dam, South Dakota, to the confluence of the Grand River, Missouri, and includes the major tributaries thereof (lower Platte, lower Kansas Rivers). The Interior Highlands Management Unit (IHMU) includes the Missouri River from the confluence of the Grand River, Missouri, to the confluence of the Mississippi River, Missouri, and the Mississippi River from Keokuk, Iowa, to the confluence of the Ohio River, Illinois. The Coastal Plain Management Unit (CPMU) includes the Mississippi River from the confluence of the Ohio River, Illinois, to the Gulf of Mexico, Louisiana, and includes the Atchafalaya River distributary system, Louisiana.

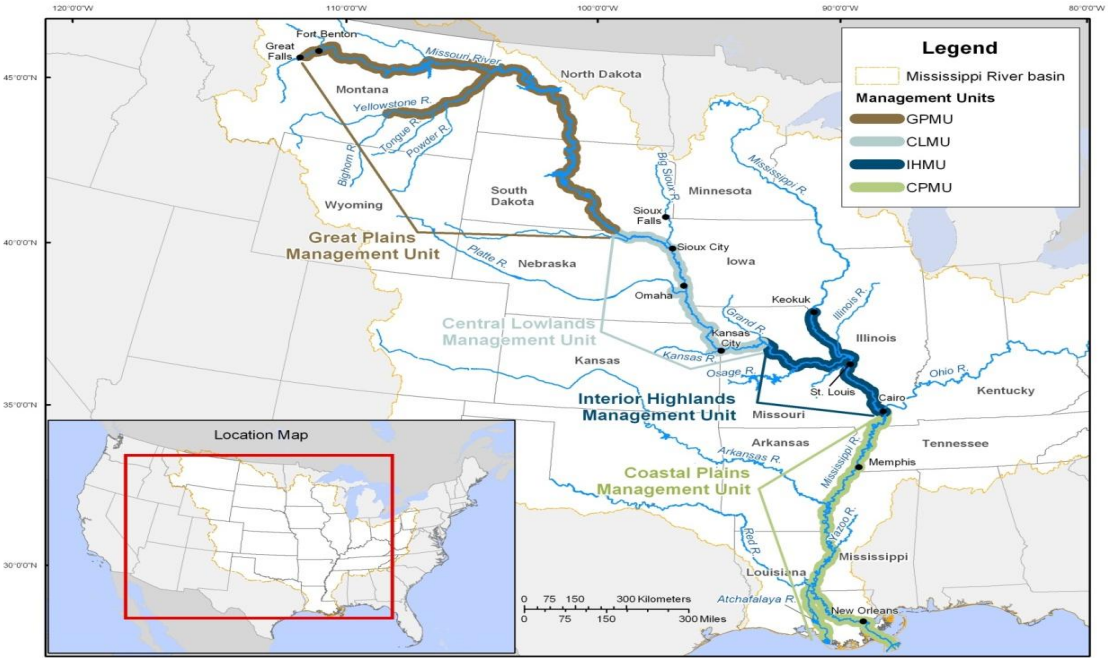

Figure IV-3a. Map depicting pallid sturgeon management units

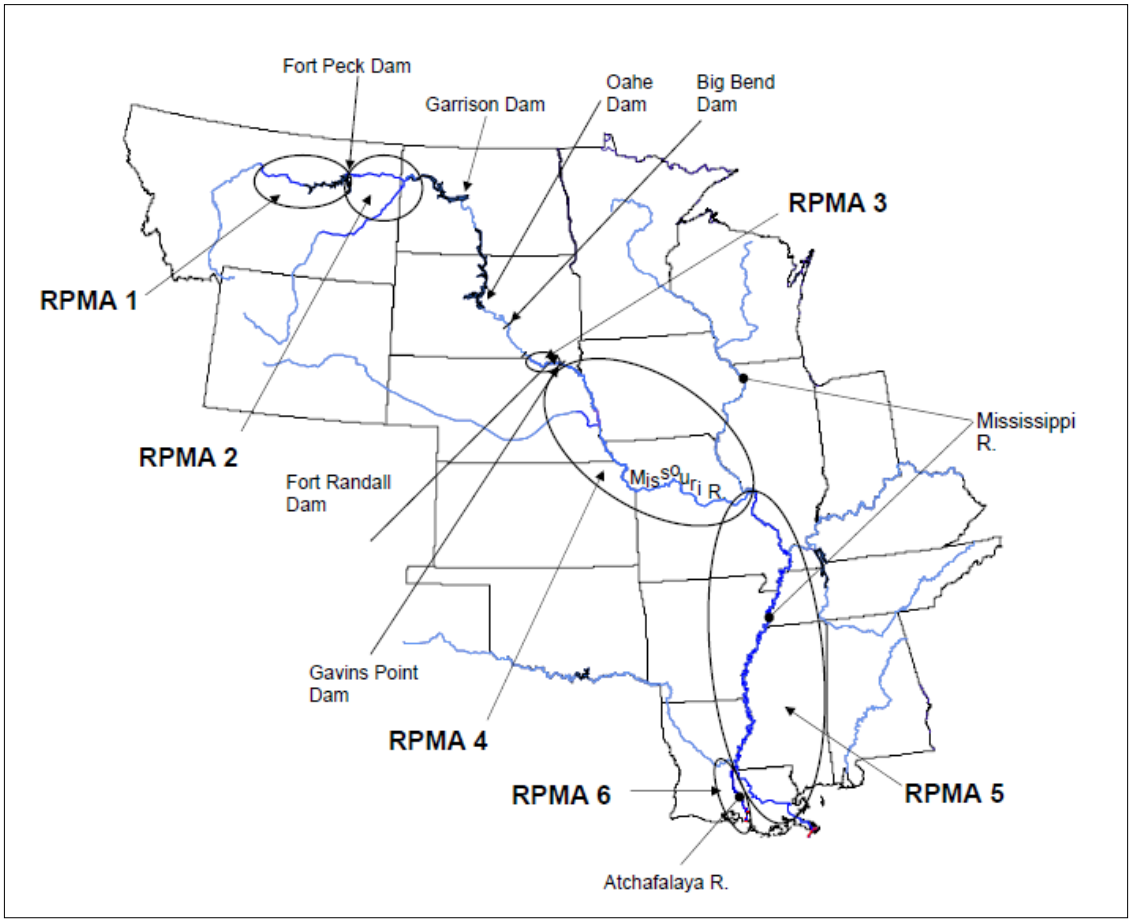

Figure IV-3b. Map depicting PS range. Outlined areas correspond with approximate locations of RPMAs as designated in the initial PS Recovery Plan (USFWS 1993). Map not to scale. Source: Pallid Sturgeon 5-year Review (USFWS 2007)

PS differ in body size, age to sexual maturity, and population size throughout their range (Murphy et al. 2007; USFWS 2007). PS from the CPMU reach much smaller total lengths (typically <39 in TL) than PS from the GPMU, which are commonly reported as reaching lengths of >39 in TL (Brown 1955; Kallemeyn 1983; Keenlyne & Maxwell 1993; Bramblett & White 2001; Killgore et al. 2007b; USFWS 2007). This latitudinal difference in size has been attributed to shorter growing seasons in cooler water and the need for sturgeon in cold climates to allocate more energy (i.e., larger bodies) for survival in a harsher environment (Killgore et al. 2007b). Conversely, some studies indicate that increased temperatures in the southern range of PS may shorten the growing season (Power & McKinley 1977; Conover 1990). Alternatively, it has been suggested that PS may use southern reaches of their range (i.e., middle and lower Mississippi River) for feeding habitat and as a growth period, and then migrate to more northern reaches (i.e., Missouri River and major tributaries) as adults for spawning habitat (Killgore et al. 2007b). PS in the GPMU are also genetically distinct from PS in the CLMU and IHMU and the Atchafalaya River distributary (included in the CPMU) (Campton et al. 2000; Tranah et al. 2001). These differences highlight the importance of thorough research throughout the entire range of the PS.

GPMU

The most recent available estimates suggest there are approximately 45 wild adult PS remaining in the most upstream portion of the GPMU (previously RPMA 1), which includes the Missouri River from the confluence of the Marias River to the headwaters of Fort Peck Reservoir, Montana. All are thought to be older adults (USFWS 2007). Natural recruitment is not thought to have occurred in this area over the last 20 years (Gerrity et al. 2008), so stocking of juveniles and larvae began in 1997 and continues today (USFWS 2007). In this region, PS are hatchery-reared from broodstock captured in the region at the Gavins Point National Fish Hatchery until age-1 and subsequently released (Gerrity et al. 2008). Recent collection data reveal that stocking efforts are working to alleviate extirpation of the species in this section of the GPMA (USFWS 2007). Although historical population demographics from pre-altered habitats are unknown, the PS population from downstream of Fort Peck Dam to the headwaters of Lake Sakakawea, North Dakota, and from the Yellowstone River below the confluence of the Tongue River, Montana (Previously RPMA 2), is thought to have declined by 40%-58% since the 1960s (Keenlyne 1989; USFWS 2007; Braaten et al. 2009). Latest estimates suggest that there are around 160 wild sturgeon remaining in this section of the GPMU, and that there is little to no natural recruitment (Klungle & Baxter 2005; USFWS 2007). Population estimates and forecasts suggest that natural populations in this section of the GPMU will be extirpated between 2016 and 2018 (Kapuscinski 2002; Klungle & Baxter 2005). However, stocking efforts are currently in place and hatchery-reared juvenile PS are being released until a population size of 1,700 individuals is reached (Braaten et al. 2009).

CLMU

There are no naturally occurring wild PS remaining in the most upstream portion of the CLMU, including the Missouri River downstream of Fort Randall Dam to Lewis and Clark Lake (formerly RPMA 3), so the entire population is made up of hatchery-reared fish and translocated wild PS (USFWS 2007). Stocking in this region began in 1997 and continues presently, and sturgeon sampling efforts have collected five out of six age classes that were stocked in this study area (Shuman et al. 2005).

A recent PS study conducted in a 50-mile reach of the lower Missouri River downstream from the confluence of the Platte River estimated a population size much higher than those in the GPMU (Steffensen et al. 2012). In this reach, 492 individuals (38 were recaptures) were collected between 2008-2010 (Steffensen et al. 2012). Of those, 93 were wild PS, and 399 were hatchery-reared PS (Steffensen et al. 2012). This count is slightly lower than the records from 1990-2005, which reported 117 unique wild PS from the Missouri River below Gavins Point Dam to the confluence of the Mississippi River (formerly RPMA 4)(USFWS 2007). It is currently unclear whether or not natural recruitment occurs in this study area (USFWS 2007).

IHMU

It is still unclear if there is any natural recruitment in the lower Missouri River, from Gavins Point Dam to the confluence of the Mississippi River (Steffensen et al. 2010; USFWS 2007). Between 1994 and 2008, nearly 80,000 hatchery-reared PS had been released into the lower Missouri River, and as of 2008, only 1% had been recaptured (Steffensen et al. 2010).

Wild PS are more frequently captured in the middle Mississippi River (MMR), which extends from the confluence of the Missouri River to the confluence of the Ohio River, than in the GPMU and CLMU. In a collaborative sampling effort between 2002 and 2005, researchers from the USACE, Missouri Department of Conservation, and Southern Illinois University, captured 148 PS, with only 12 fish of hatchery origin (USFWS 2007). In the MMR, the pallid : shovelnose sturgeon ratio ranges from 1:36 to 1:77 pallid : shovelnose (Killgore et al. 2007a). Age-0 PS have been collected in the MMR, although it is unknown where spawning occurs (Hrabik et al. 2007).

CPMU

Between 1996-2006, 162 PS were collected in the LMR, and >500 individuals have been captured to date (Killgore et al. 2007a, USFWS database 2013). Pallid : shovelnose ratios vary between 1:6 to 1:30 pallid : shovelnose (Killgore et al. 2007a). There is a relatively large population (1:6 ratio of pallid : shovelnose) of PS in the Atchafalaya River distributary than in other parts of the pallid sturgeon range, although it is still unclear whether or not natural recruitment occurs in this area (Killgore et al. 2007a; USFWS 2007). More than 600 PS have been captured and marked in the Atchafalaya to date (USFWS database 2013). Age-0 PS have been captured in the LMR, although it is unclear exactly where and when spawning occurs (ERDC, unpublished data; Hartfield et al. 2013).

LMR Recovery Status

The USFWS (1993) criteria to down list PS from endangered to threatened include a population structure with at least 10% sexually mature females, and sufficient numbers in the wild to maintain population stability. USFWS (2007) conducted a 5-Year Review of the conservation status of the PS, including an assessment of status in each identified RPMA throughout its range. They identified a lack of adequate information on population size, recruitment, and trends in RPMAs 5 and 6 (Mississippi and Atchafalaya rivers, respectively), and the continued need for artificial supplementation efforts in RPMAs 1, 2, 3, and 4 (reaches of the Missouri River), concluding that the PS did not meet criteria for downlisting to threatened status or for delisting in any portion of its range. The 5-Year Review recommended revision of the PS Recovery Plan and criteria for recovery.

A draft revision has been released by USFWS (2013), which notes significant genetic structure through the range, redefines management units, and identifies the potential of delisting by management area. The primary strategy for recovery of pallid sturgeon is to: 1) conserve the range of genetic and morphological diversity of the species across its historical range; 2) fully quantify population demographics and status within each management unit; 3) improve population size and viability within each management unit; 4) reduce threats having the greatest impact on the species within each management unit; and, 5) use artificial propagation to prevent local extirpation within
management units where recruitment failure is occurring. Pallid sturgeon recovery will require an increased understanding of the status of the species throughout its range; developing information on life history, ecology, mortality, and habitat requirements; improving our understanding of some poorly understood threat factors potentially impacting the species; and using that information to implement management actions in areas where recovery can be achieved.

Fat Pocketbook Mussel

The fat pocketbook mussel *Potamilus capax* is a freshwater pearly mussel native to the Ohio River system and Mississippi River drainage (Watters et al. 2009). Fat pocketbook mussels (FPM) belong to the family Unionidae, which is one of two families of pearly mussels that occur in North America (Watters et al. 2009). This species was originally described as *Unio capax* Green 1832, but was later placed in the genus *Potamilus* Rafinesque (Watters et al. 2009). This species is aptly named for its valve morphology, which is highly inflated and obovate (MMNS 2001; Watters et al. 2009). This species is a relatively large species, with adults sometimes reaching over 5-inches in length (USFWS 1989). The FPM was listed as endangered throughout its range by the U.S. Fish and Wildlife Service in 1976, and a recovery plan was issued in 1989 (USFWS 1976; USFWS 1989). The decline of the FPM has been attributed to several anthropogenic impacts, including water contamination and loss of habitat, particularly to perturbations associated with river navigation and flood risk management (USFWS 1989). Because its shell is too thin, this species is of no commercial value (Harris & Gordon 1990). An updated 5-year review reported that the FPM species status is improving based on increases of site records throughout its range (USFWS 2012b).

Habitat

FPM occupy depositional areas of large, slow moving rivers, and museum records suggest that this species requires flowing water and stable substrates (USFWS 1989; Watters et al. 2009). This species is typically found in sand and silt substrates, but has also been collected in mud, clay, and fine gravel substrates in depths ranging from a few inches to ten feet in depth (Baker 1928; Parmalee 1967; Harris & Gordon 1987; USFWS 1989; Harris & Gordon 1990; USFWS 2012b). The FPM, which in some populations has a very thin shell, is able to survive in deep depositional areas of silt, and it has been suggested that prior to anthropogenic habitat alteration, this species was probably common in oxbows and sloughs (Miller & Payne 2005). In the lower Mississippi River, FPM have been found in sand in secondary channels and in a mixture of sand, silt, and mud in side channels (USFWS 2012b).

Movement

Freshwater mussels generally follow two movement patterns, vertical and horizontal, and movement is thought to be seasonal and/or related to reproduction or habitat suitability (Peck 2010). FPM populations threatened by habitat modification (e.g., dredging, channel maintenance, road/bridge construction) have been relocated to more suitable habitats (Peck 2010). After relocation, this species has a tendency to move less than do non-relocated individuals (Peck et al. 2007). FPM have an average range of approximately 21 yds, but some individuals have been noted to move >165 yds (Peck et al. 2007). A 25 month telemetry study of the movement patterns of the FPM in Arkansas demonstrated that the average home range of this species is 117.0 yds, and most movements are downstream in unimpounded reaches (Peck 2010).

Feeding

Like other freshwater mussels, the FPM feeds by circulating water through its gills, removing particulate organic matter (Miller & Payne 2005; EPA 2007). It has been demonstrated

that different bivalve species filter different sized particulate matter, although the specific diet of this species is unknown (Silverman et al. 1995).

Reproduction

Gravid FPM have been found between June and December and this species is likely bradytictic (Baker 1928; Oesch 1984; USFWS 1989; Roe et al. 1997; Watters et al. 2009). Fertilization occurs in spring after sperm are released upstream of female mussels and are siphoned into the gills (Baldridge et al. 2007; USFWS 2012b). The posterior portion of the outer gills is the marsupial region in this species (Watters et al. 2009). Glochidia are packaged in white, fragile conglutinates (Utterback 1916). Glochidia are axe-head or hatchet-shaped with hooks along the lateral margin of the ventral flange and measure 0.105 x 0.185 mm (Utterback 1916; Oesch 1984). The only known host species for FPM is freshwater drum *Aplodinotus grunniens* Rafinesque, but the method of glochidial attachment remains unknown (Watters et al. 2009; USFWS 2012b). It has been suggested that glochidial attachment may occur upon ingestion of the gravid adult by the molluscivorous host (Dillon 2000; Barnhart et al. 2009). FPM less than 5 years in age have been collected in the St. Francis system, Arkansas, and in the LMR system, indicating successful reproduction and recruitment (W.T. Slack, ERDC, pers. comm.; USFWS 2012b).

Distribution and Abundance

Historically, the FPM occurred in the upper Mississippi and Ohio rivers and the major tributaries thereof, but this range has declined by >70% (Harris & Gordon 1987; NatureServe 2012). There are museum records of FPM from the upper Mississippi River from the confluence of the Minnesota and St. Croix rivers to the White River, but this species has not been found there since the 1980s and is thought to have been extirpated from many of those sites (EPA 2007; NatureServe 2012; USFWS 2012b). At the time of listing, the FPM was only known from one locality, the St. Francis Floodway in Arkansas, and in 1989, an updated recovery plan was published with additional records from the St. Francis River and several small drainage ditches and tributaries (USFWS 1989, 2012b). Since 1989, additional FPM populations have been found in the St. Francis system, LMR, White, Ohio, Wabash, lower Tennessee, and Cumberland Rivers (USFWS 2012b).

LMR Recovery Status

Recovery criteria require protection of the St. Francis River population of FPM, and location and protection of at least two additional viable populations in two other river systems within the historical range of the species. The Ohio River population has expanded in recent years, and a population has been discovered in the LMR. Both new populations are considered viable, based on the presence of juvenile and subadult specimens. Neither range nor population size of FPM have been defined or quantified in the Ohio and LMR, however, both populations are being considered by state and Federal agencies during project planning, and are protected to some degree through formal and informal consultations.

PART V: LMR ENVIRONMENTAL BASELINE

Historical and Current Species Baselines in the LMR

Interior Least Tern

The historical distribution and abundance of ILT is poorly documented. Hardy (1957) reported the few documented ILT historical records of occurrence and nesting on the LMR, but surmised that the birds nested at many localities along the river. Downing (1980) reported 300 birds in 11 colonies during an aerial survey of the Mississippi River, and noted the greatest concentration of birds occurred between Osceola, Arkansas, and Cairo, Illinois. These primary historical sources of information were used to quantify a 1985 estimated population size of 350 to 400 adult ILT in the listing rule (50 FR 21789). The 1990 Recovery Plan utilized data from Sidle et al. (1988) and increased minimum LMR population estimate to ~2,300 adults (U.S. Fish and Wildlife Service 1990).

Nesting colonies have been monitored in the LMR for over 25 years (Figure V- 1) and data have shown a significant increase in ILT numbers since initiation of the Lower Mississippi River Environmental Program (LMREP) in 1982. ILT are currently distributed along an 800 mile reach of the LMR between the confluence of the Ohio River and Baton Rouge, LA. The population level has ranged from 8,000 – 18,000 birds over the past 9 years, and the drainage basin recovery goal (2,500) has been exceeded for more than 20 years. Some proportion of the increase in adult ILT numbers has been attributed to improved survey efforts and efficiency (Lott 2006). Changes in survey methods utilized in the LMR, and extending survey reaches correspond to some degree with higher ILT counts (Figure V-1). The occurrence of large numbers of ILT within the LMR un-impounded navigation system has also been attributed, in part, to higher elevation sand and gravel bars associated with channel training dikes (Lott 2006).

USACE analyses indicate that habitat quantity has remained relatively stable and underutilized by breeding/nesting ILT for the past two decades (USACE 2008). USACE is finalizing a habitat trend analysis of islands for the LMR (Guntren et al. 2012). The LMR recovery goal (2,500 birds) has been exceeded every year since 1990. The range-wide ILT numerical recovery goal (7,000 birds) has been annually exceeded on the LMR alone since 2003 (Figure V-1).

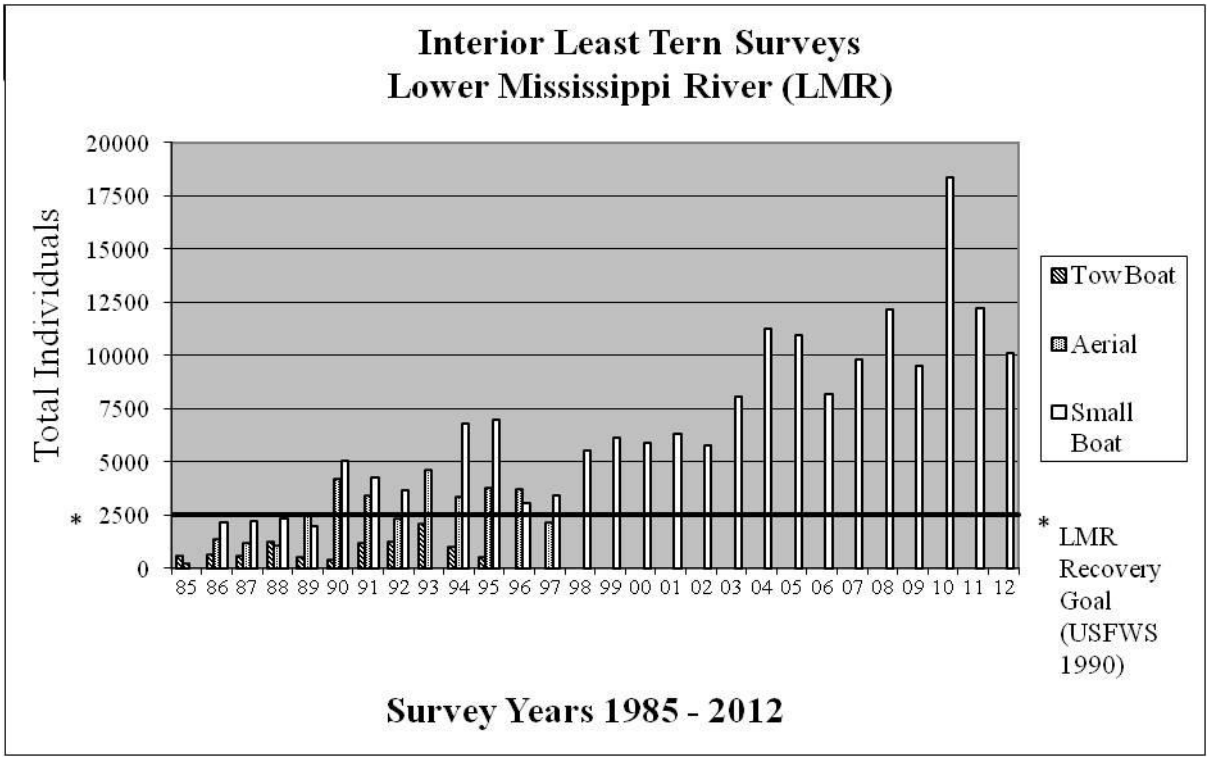

Figure V-1: ILT Population Survey Results in the Lower Mississippi River, 1985-2012 (Mike Thron, USACE).

Pallid Sturgeon

The PS historical baseline in the LMR is undocumented. Prior to listing, collection records of PS in the LMR were extremely rare, and the USFWS was able to document only 35 observations of the species from the entire Mississippi River (Keenlyne 1989), 28 of these from the LMR and none from the Atchafalaya River. PS population size has not been quantitatively defined within the LMR, particularly considering the scope and scale of the available habitat to sample. However, in 2001, USACE initiated efforts to develop sampling methods for PS in the LMR, as well as studies on abundance, distribution, demography, and habitat use (e.g., Killgore et al. 2007a,b; Hoover et al. 2007, etc.). These and other collections, as well as telemetry monitoring of sonic tagged individuals have shown that PS occur throughout most of the 950 mile reach of the LMR (Bettoli et al. 2009, Killgore et al. 2007a, Kroboth et al. 2013, USFWS database 2013), and the 200 mile reach of the Atchafalaya River (Constant et al. 1997, Dean in litt. 2005-2009, Herrala & Schramm 2011, USFWS database 2013). Collections of PS in the LMR include almost 500 individuals collected between the mouth of the Ohio River and New Orleans, LA (Figure V-2)(Killgore et al. 2007a; USFWS database 2013), ranging in age from 0 – 21 years (50 to >1,000 mm fork length (FL)) (Killgore et al. 2007b, USFWS database 2013). No PS or shovelnose sturgeon have been collected below RM 85 (Killgore et al. 2007a; Hartfield, in litt. 2001-2010; Kroboth et al. 2013) Over 600 PS ranging from 400 to >1000 mm FL have been collected from the Atchafalaya River distributary of the LMR (USFWS database 2013).

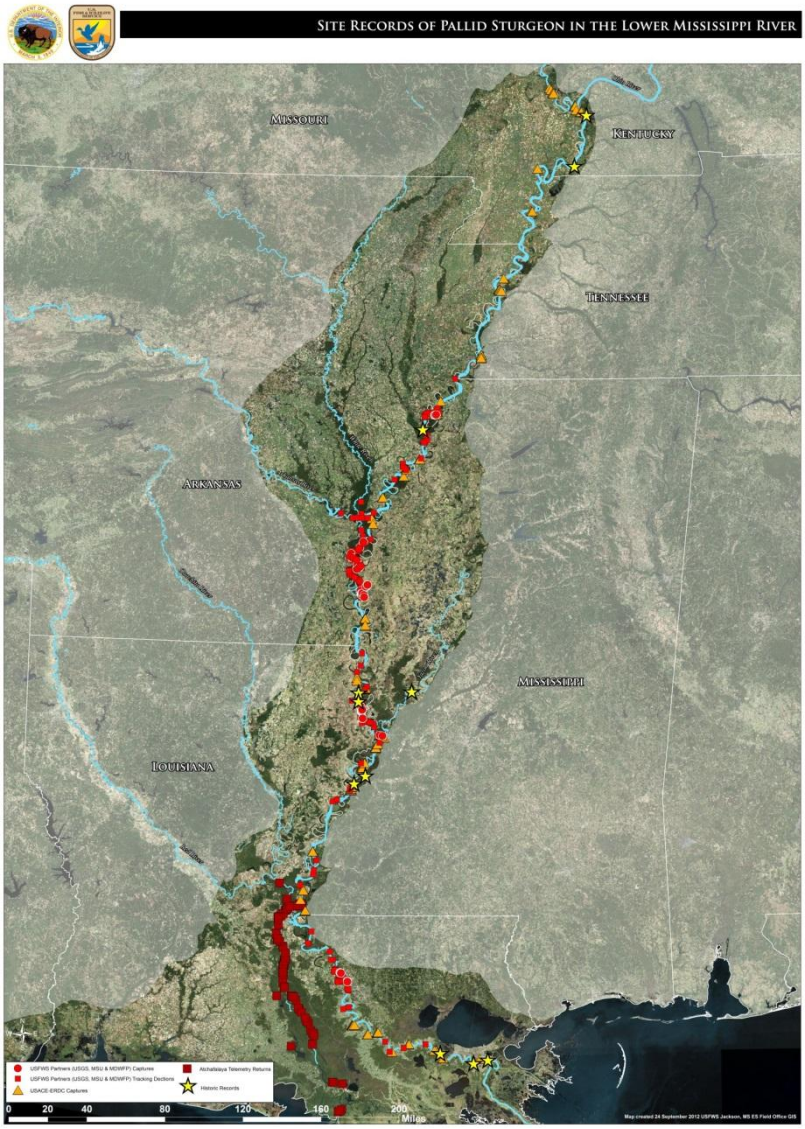

Figure V-2: Capture and telemetry locations of PS in the LMR and Atchafalaya Rivers. Collection and telemetry records by ERDC, USGS, and USFWS. Map developed by Mississippi Field Office, U.S. Fish and Wildlife Service.

Although PS population size in the LMR has not been quantified, available data suggest a substantial population when compared to fishing effort and fish species composition. Killgore et al. (2007a) found that PS comprised 2.2% of fish captured on winter set trotlines, and ranked 5th in frequency of capture out of 22 species collected. During two years of trotline sampling at Vicksburg and Tunica, MS, PS comprised 2.4 and 2.5%, respectively, of fish collected at both locations, and ranked 4th in frequency of capture out of 11 species collected (Aycock et al. 2012) Recaptures of PS are also rare in the LMR. Killgore et al. (2007a) reported only five PS recaptures over seven years. In another study that conducted two years of monthly PS collection and telemetry efforts in a 30-mi reach of the Mississippi River, only a single PS recapture occurred out of >60 PS collected, tagged, and released, even though telemetry results indicate most PS remained within the sample reach (Kroboth et al. 2013).

There is also evidence that the LMR PS population can sustain removal of substantial numbers of individuals from the population. Bettoli et al. (2009) conservatively estimated that 2% of the commercially harvested sturgeons in the Tennessee reach of the LMR were PS (169 females over two seasons). Commercial harvest for sturgeon caviar has occurred annually in the Tennessee and Missouri reaches of the LMR for more than two decades. While baseline data on LMR PS is lacking, the persistence of the species following more than two decades of harvest pressure on mature PS females, suggests the population is relatively robust.

Additional evidence of population size has recently been developed in association with evidence of persistent and periodic entrainment losses of LMR PS. During an emergency opening of the Bonnet Carre Spillway in 2008, the USACE and USFWS estimated up to 92 PS were injured or killed due to entrainment (USFWS 2009a). Bonnet Carre has been opened four times since the species was listed (1994, 1997, 2008, and 2011). Pallid sturgeon are freshwater fish, and once entrained, their only choice is to move into the brackish waters of Lake Pontchartrain where they likely perish or move up to the structure as the water recedes where they may be rescued as was done in 2008 and 2011. Other diversion structures that have been operating for one to five decades (Old River Control Complex, Davis Pond) are also known to entrain PS. Pallid sturgeon entrained at Old River Control Complex enter the Atchafalaya River, but it is unknown if these fish can spawn in the relatively short reach (137 river miles) between the structure and the Gulf of Mexico near Morgan City, LA. It is also unlikely that pallid sturgeon can swim from the Atchafalaya River back into the Mississippi River due to head differential through the diversion structures. While episodes of commercial harvest or entrainment constitute substantial periodic or continuous localized loss of individuals to the PS population within the specific river reaches, scientific collection efforts indicate the species has persisted within the commercially harvested and diversion reaches of the LMR (e.g., Killgore et al. 2007 a, b; Kroboth et al. 2013).

LMR PS population demographics have been poorly defined but recruitment has been documented by capture of multiple age classes (Figure V-3, Killgore et al. 2007a) and capture of larval PS at several locations between the confluence of the Ohio River and Vicksburg, MS. Adult PS annual mortality is low (<12%) in the LMR, compared to the Middle Mississippi River (>35%) (Killgore et al. 2007b) where commercial fishing was just recently banned (USFWS 2010b). There are latitudinal morphometric variation and length-at-age differences across the range (Murphy et al. 2007), suggesting that management goals should be reach-specific. Specific spawning and rearing habitats for PS are poorly known but surmised to include gravel bars (spawning), and secondary channels and flooded sand islands (larval and juvenile recruitment). Telemetry studies in the LMR have shown larger size classes of PS use multiple channel habitats, including point bars, secondary channels, crossovers, wing dikes, island tips, natural banks, and revetted banks (Kroboth et al. 2013).

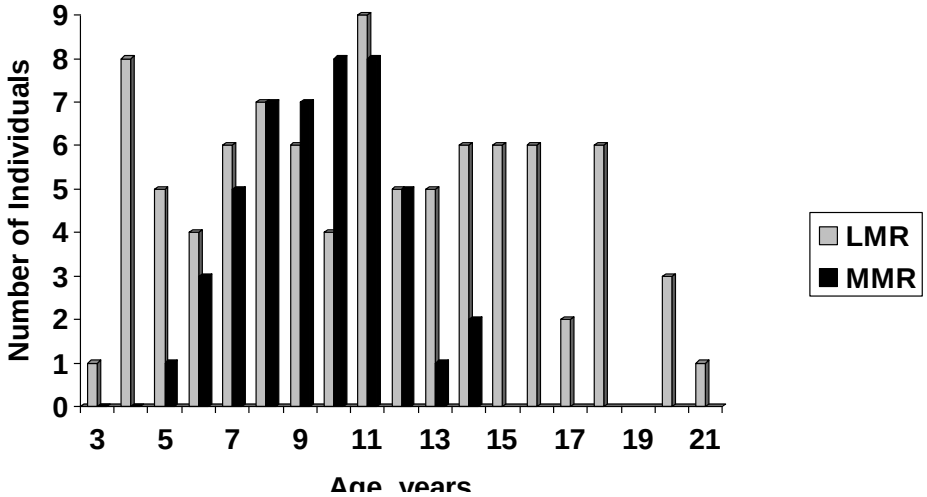

Figure V-3. Age distribution of PS captured in the Lower (LMR) and Middle (MMR) Mississippi River (Killgore et al. 2007b).

Fat Pocketbook Mussel

There are no historical records of FPM from the CIP footprint (i.e., active channel) in the LMR (Figure V-4). Recent collections of FPM from the LMR indicate a widespread population (Figures V-4, V-5), but intense sampling efforts are needed to assess abundance in this region. Most of the LMR collection records are from secondary and side channels along the river, particularly Gilliam Chute, in Jefferson County, Mississippi (Figure V-6) (USFWS 2012b). Specimens have also been collected at St. Catherine's Creek National Wildlife Refuge. A single young individual was collected in a trawl sample below a chevron dike, Bolivar County, Mississippi (W.T. Slack, pers. comm.). Live and fresh dead specimens have been collected from secondary channels between River Miles 410 – 800, but sampling has been insufficient to determine if and where viable populations occur in the river.

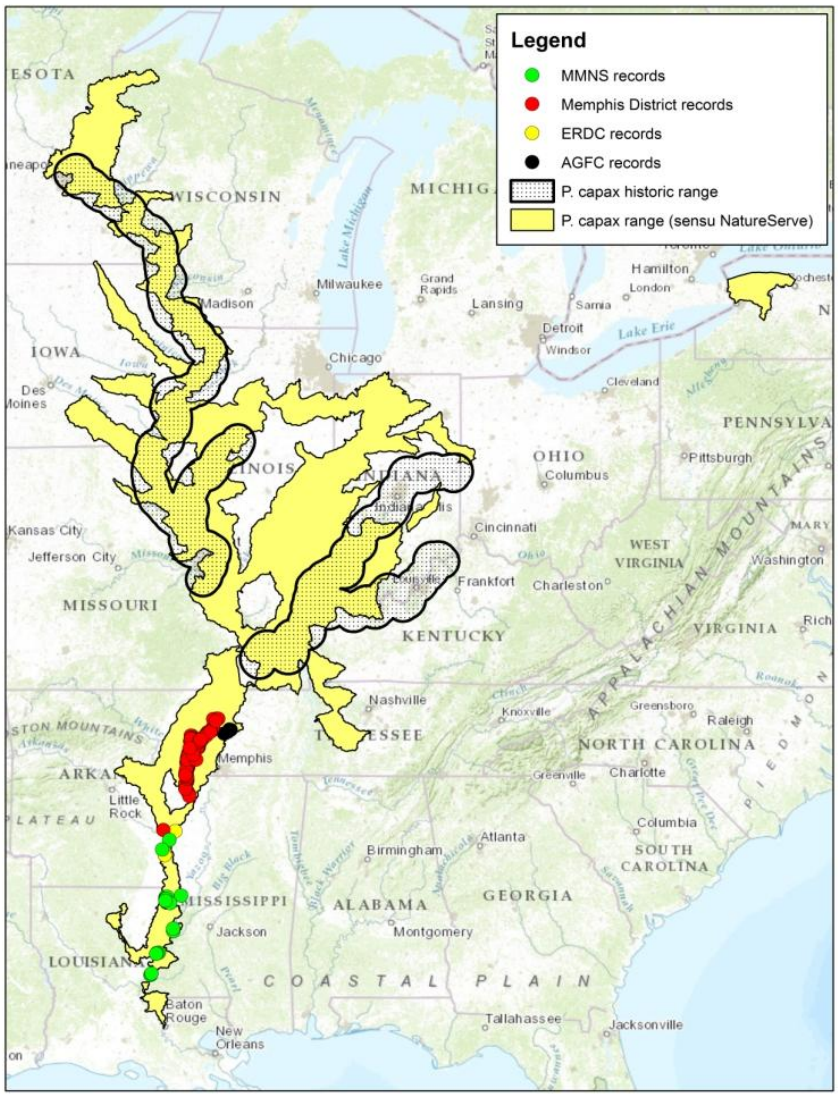

Figure V-4. Historical and present-day distribution of *Potamilus capax*. Collection records, both published and unpublished, provided by Mississippi Museum of Natural Science, Jackson, MS, USACE Memphis District, Memphis, TN, Arkansas Game and Fish Commission, Little Rock, AR, USACE-ERDC, Vicksburg, MS, and NatureServe Explorer.

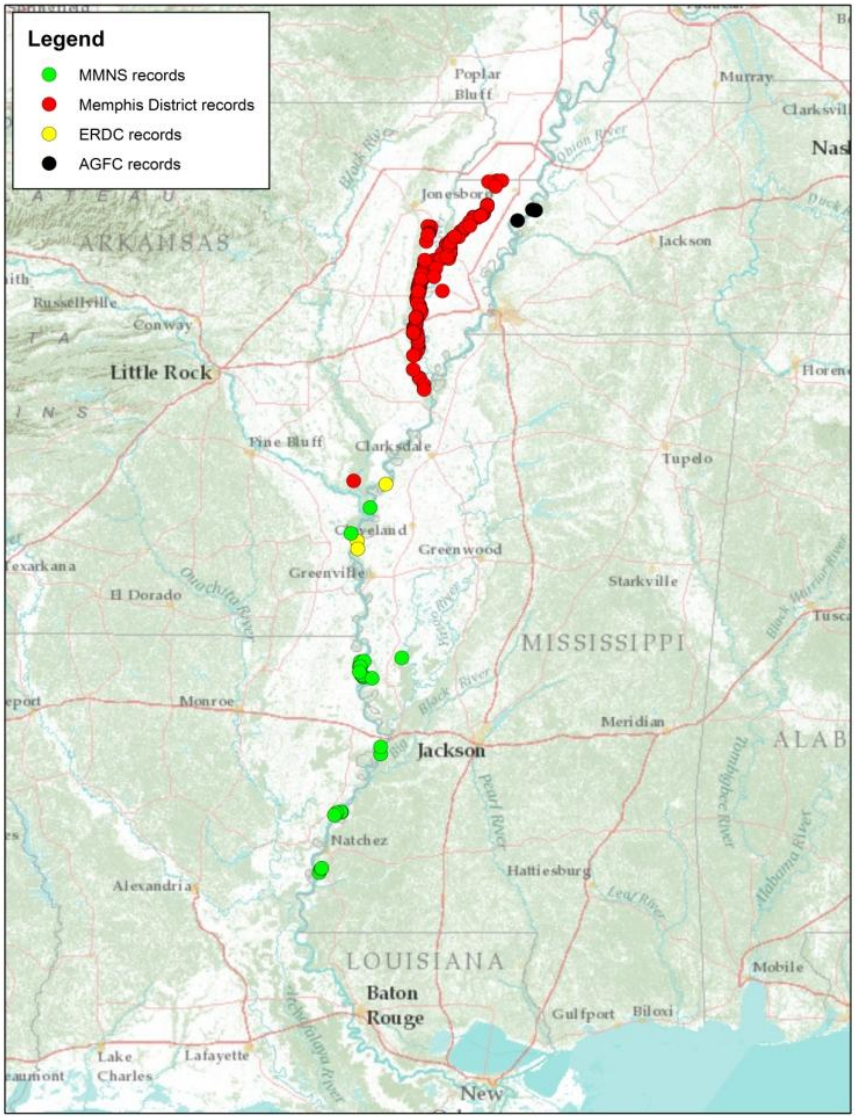

Figure V-5. Collection sites of *Potamilus capax* in the lower Mississippi River and some tributary watersheds. Collection records provided by Mississippi Museum of Natural Science, Jackson, MS, USACE Memphis District, Memphis, TN, USACE-ERDC, Vicksburg, MS, and Arkansas Game & Fish Commission, Little Rock, AR.

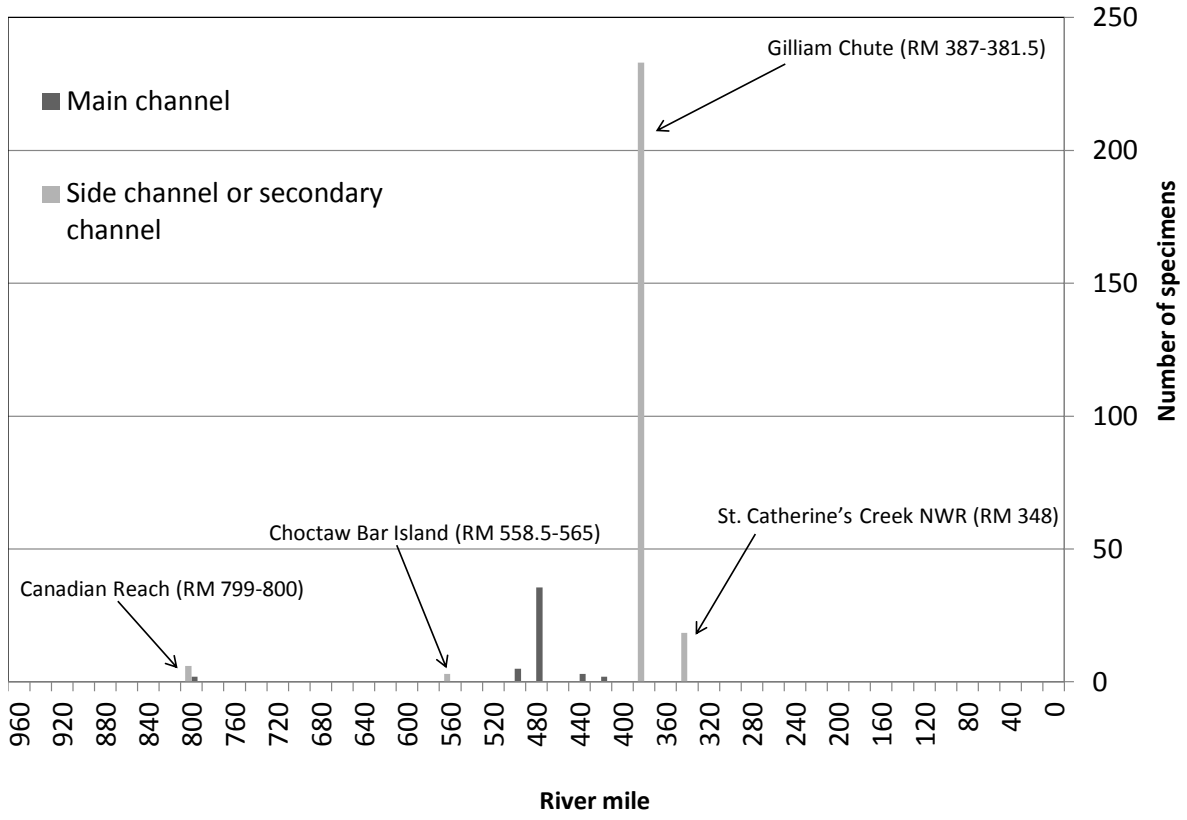

Figure V-6. Collections of *Potamilus capax* in the Lower Mississippi River including specimens collected in the Mississippi River main channel, side channels, and secondary channels. Data from ERDC.

Factors Affecting Species

Several concerns have been identified for the priority species in the LMR (USFWS 1989, 2007, 2012c). These include: habitat loss and modification for all three priority species, human disturbance to ILT nests and chicks, commercial harvest of PS, dredge entrainment of PS, sand and gravel mining entrainment and spawning habitat degradation, entrainment of PS through water control structures, effects of pollution and contaminants on all three species, and hybridization of PS with shovelnose sturgeon. Ongoing and proposed actions required to fully assess these factors are identified below.

Habitat Loss and Modification

While it is likely that habitat modification has the potential to seriously affect all three priority species, there is little evidence of direct impacts in the LMR, i.e., knowledge and numbers of PS and ILT have increased relative to historical pre-modification conditions, and the occurrence of FPM was first documented from the LMR post-modification.

Appropriate habitat for PS is generally characterized as large, deep, turbid, fast, and free-flowing rivers, with spawning migration and success linked to seasonal high flow events

common to a natural hydrograph. These characteristics are common in the LMR throughout nearly all of its length. The LMR appears to contain the most extensive and possibly the best quality habitat within the species' range, including complex channel habitats, numerous secondary channels and islands, and widespread gravel bars suitable for spawning. While, the location and complexity of channel habitats has been modified over time by river engineering under the CIP, the potential adverse effects on PS recruitment are poorly documented or understood.

Habitat loss and modification does not appear to be a factor affecting either ILT or FPM in the LMR. As noted previously, potential LMR nesting habitat for ILT currently exceeds use by the species. The expansion of the FPM range into LMR secondary channels appears to result from recent exploitation of developing habitat conditions created within USACE dike fields, however, this is poorly documented and understood.

Maintenance Dredging

Maintenance dredging of the navigation channel is required in the LMR navigation channel, particularly within crossovers and harbors at low river stages. Dredging has been shown to take shovelnose sturgeon in the Middle Mississippi River (MMR), suggesting some level of take of PS may be occurring through dredge entrainment in the LMR. However, entrainment risk may be reduced in the LMR relative to the MMR due to the larger LMR channel and complexity. Furthermore, entrainment risk varies depending on type of dredge (cutter head, hopper, mechanical), the habitat being dredged, and size-dependent swimming capability of sturgeon (Hoover et al. 2009; Hoover et al. 2011). Dredging near nesting sandbars can disrupt ILT nesting activities. Although mussels can be subject to dredge entrainment, habitats where FPM have been found in the LMR are not subject to dredging, therefore, dredge entrainment is not considered a factor affecting FPM in the LMR.

Water Diversion Entrainment

Entrainment of PS through water control and floodway structures (i.e., Bonnet Carre floodway, Davis Pond, and the Old River Control Complex (ORCC)) is known to occur in the LMR. Water control and floodway structures are separate issues from the CIP, and are not covered under this conservation plan. The USACE has consulted with the USFWS over the 2008 spillway operation of Bonnet Carre and the proposed construction of two new diversion structures, White Ditch and Convent/Blind River. Biological Opinions have authorized take resulting from the emergency operation of Bonnet Carre, as well as possible future take of PS at the two planned structures (USFWS 2009a, 2009b, 2010a). Emergency consultations for Morganza and New Madrid floodways that were operated during the 2011 flood were also completed. The USACE and USFWS need to complete formal consultations over entrainment of this species at Davis Pond, Caernarvon, ORCC, and other proposed structures. Entrainment studies at LMR diversions, excluding ORCC but including Bonnet Carre and Davis Pond, have been completed by ERDC. The final report will document sturgeon entrained through existing diversions, document sturgeon occurring in the Mississippi River near the vicinity of existing diversions, and present population viability models for risk analysis. Results of these studies will be used to quantify entrainment of PS and shovelnose sturgeon at diversions over the project life. Localized entrainment losses will be weighed against population size and recruitment levels of PS throughout the LMR. USACE is working to identify engineering designs to minimize

entrainment losses through water control structures and has conducted rescue and recovery efforts to minimize PS population impacts due to floodway operations.

Sand and Gravel Mining

Regulatory branches of the USACE issue permits for sand and gravel mining dredging in the LMR. Regulatory issues are not directly related to the CIP and are not addressed under this conservation plan. MVD sand and gravel dredging permits require avoidance of ILT nesting colony disturbance by maintaining buffers from nesting sites; permits also prohibit mining within all dike fields and secondary channels, the habitats occupied by FPM.

The USFWS has expressed concerns that permitted commercial mining dredges in the Mississippi River can entrain PS and degrade gravel bars where sturgeon spawn. ERDC has conducted multiple studies on sturgeon susceptibility to sand and gravel dredges (ERDC-EL 2009) and provided the following information:

1) A chronology of sturgeon life history stages was compiled by sampling the temporal occurrence of larvae, juvenile, and adults using Missouri trawls. Application of these data can establish operating windows when dredges would have minimal impacts on spawning adults and young-of-year.
2) Entrainment of sturgeon was directly assessed during dredging operations by sampling dredged material and overflow, and field sampling for sturgeon in the vicinity of an active dredge. No sturgeons were collected.
3) Measurements of swimming performance by different size-classes of sturgeon were conducted and compared to suction velocities created by dredges. Data provided quantitative assessment of risk for young-of-year sturgeon of different sizes.

An initial survey of gravel bars in the LMR was conducted by ERDC (D. Biedenharn and M. Corcoran) and maps developed of their locations. Further potomological studies are necessary to fully evaluate effects of sand and gravel dredging on protected species. Currently, special conditions are applied to the permits to avoid potential impacts to the species and can be modified as new information becomes available.

Commercial Harvest of Pallid Sturgeon

Commercial harvest of sturgeon for caviar and smoked flesh has occurred to various degrees in the LMR since the 1800s. Harvest for shovelnose sturgeon has been closed for over a decade in the Arkansas, Mississippi, and Louisiana reaches of the LMR; however, harvest of shovelnose sturgeon for caviar has increased in the LMR reaches of Tennessee, Kentucky, Missouri, and Illinois where they co-occur with pallid sturgeon. Based on data that indicated significant numbers of mature female pallid sturgeon were being taken during commercial harvest of shovelnose sturgeon in the Tennessee reach of the LMR (Bettoli et al. 2009), and high mortality of PS in reaches where commercial harvesting was still legal (Killgore et al. 2007b), USFWS listed the shovelnose sturgeon within the sympatric range of PS as threatened due to similarity of appearance (USFWS 2010b). This action effectively eliminated the loss of PS to commercial caviar harvest in the LMR and MMR.

Pollution and Contaminants

Pesticides and heavy metals have been detected in the tissues of sturgeon throughout the United States and could potentially affect all three priority species to varying degrees. These contaminants cause reproductive failure and population declines, and pose potential health risks to consumers of sturgeon meat and caviar. Shovelnose sturgeon in the Mississippi and Missouri Rivers have been found with high levels of DDT and chlordane and hermaphroditic individuals have been observed (Ruelle & Keenlyne 1993), suggesting that contaminants could impact PS to some degree. While water quality has improved in the LMR since implementation of the CWA, historical and recent water quality data for the LMR needs to be analyzed to determine the significance and trends of pollution and contaminants in the LMR. Although pollution and contaminants are not directly related to the CIP, under some conditions contaminants may be re-suspended by dredging activities in contaminated sediments. The LMR is a dynamic channel constantly moving and mixing large quantities of sediment through the system. There is no indication that sediments within crossovers frequently dredged by USACE under the CIP contain contaminant levels above those considered safe by EPA.

Hydrokinetics

Applications have been made to utilize the LMR for power generation using hydrokinetic technology. Effects of hydrokinetic turbines on PS are currently undefined; however, there is potential of injury or mortality from turbine blade strikes, as well as potential behavioral effects due to electromagnetic fields and noise. USACE Mississippi River fishery data, as well as USFWS/USGS telemetry data are being used by hydrokinetic developers to identify potential impacts to PS and other fish resources. ILT and FPM are unlikely to be directly affected by hydrokinetic turbines; however, infrastructure sighting has the potential to affect these species or their habitats. Hydrokinetic turbines are not part of CIP, and their potential effects are the responsibility of the applicant and the Federal Energy Regulatory Commission.

Hybridization of Pallid and Shovelnose Sturgeon

Hybridization with shovelnose sturgeon has been identified as a threat to PS in the LMR. This hybridization was initially believed to be caused by a loss of species isolating mechanisms due to river engineering and habitat modifications. However, neither the mechanisms nor the essential habitat features have been identified. There is morphological and genetic evidence that some proportion of these “hybrids” are morphological variants of both species and have been misidentified due to allometric growth of PS (Murphy et al. 2007). There is also evidence that morphological and genetic variation interpreted as hybridization existed in LMR sturgeon populations prior to, and are unrelated to, engineered modification of the LMR (Hartfield & Kuhajda 2009, Schrey et al. 2011). Genetic and morphological studies are in progress to improve and standardize identification of river sturgeon in the LMR, and determine the significance and possible trends of hybridization as a threat to PS in the LMR (USFWS *in litt*. 2011).

PART VI: EFFECTS ANALYSIS

Effects of the Program

Bendway cutoffs constructed between 1929 and 1960 under the MR&T shortened the river by >150 mi (Winkley 1977). Since 1960, channel engineering conducted under the CIP has resulted in a loss of secondary channels and associated habitats (Williams & Clouse 2003). Therefore, the primary environmental effects of the MR&T and CIP have been the physical loss of LMR channel habitat quantity, a growing disconnect with the relict floodplain during low to moderate river stages, and a general loss of riverine habitat complexity (i.e., diversity). The responses of ILT, PS, and FPM to the effects of the CIP are evaluated below.

Interior Least Tern

There are currently no data that indicate habitat loss due to the CIP is a limiting factor for ILT in the LMR. In fact, the data suggests that overall the ILT response to the conditions resulting from the CIP has been positive. ILT population size has increased from a historical baseline of fewer than 500 birds, to a current baseline of ~10,000 or more breeding birds per season (see Figure V-1, above). Direct causes of the population increase are not understood; however, they may be related, at least in part, to: 1) Earlier and extended breeding potential due to more efficient movement of flood flows through the system (including effects of tributary impoundment and engineering) (e.g., Schramm 2004; see Figure VI-1); 2) Higher sandbars associated with dike fields (e.g., Lott 2006); 3) Dike notching and avoidance work windows implemented by the USACE under the LMREP; and/or 4) Migration of coastal breeding colonies due to better nesting and forage conditions along the LMR (e.g., Lott 2006).

Human activities near nesting sandbars can disrupt ILT nesting activities. The USACE maps ILT nesting sites and maintains 1,500 ft buffers between dredging sites and nesting sandbars during CIP construction activities in the nesting season. This distance exceeds most recommendations for buffers between waterbirds and human activities (Valente & Fischer 2011).

Terrestrialization of islands and sandbars (i.e., vegetation encroachment and accretion with the river bank) associated with dike fields has been identified as a negative factor affecting ILT. However, actions such as dike notch construction under the CIP, are being increasingly utilized to sever land-based routes used by ATV recreationists and terrestrial predators to access ILT nesting colonies.

While habitat quantity and condition is not currently considered to be negatively affecting ILT in the LMR, USACE-MVD and Districts have been actively working with partners to restore degraded secondary channels and their associated islands and bars. These activities are protecting, and enhancing ILT habitat quantity and quality throughout the LMR.

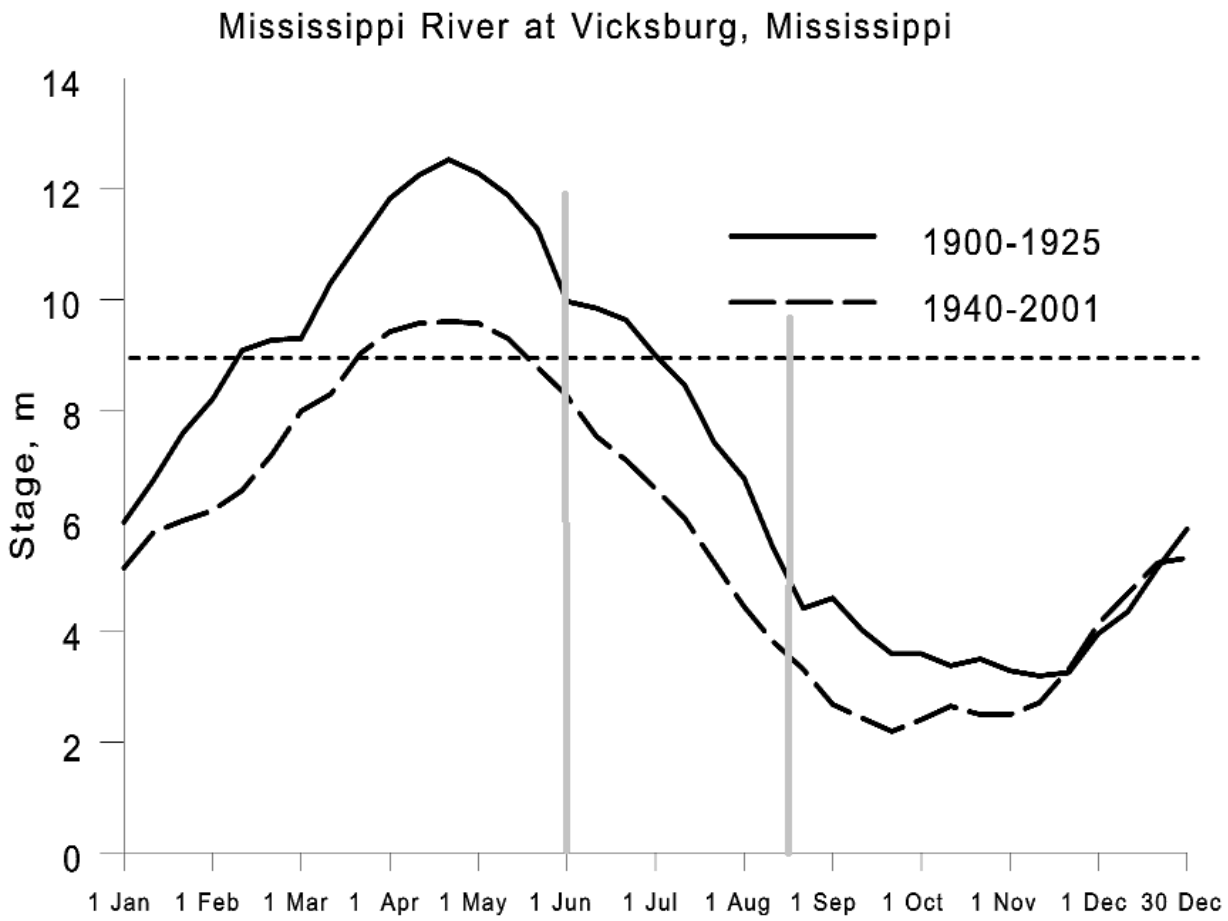

Figure VI-1: Example of the reduction in average river stage (LWRP) resulting from river engineering (1940-2001) providing prolonged periods for ITL nesting due to greater availability of emergent sandbars. Dashed horizontal line represents near bankfull stage. Perpendicular line represents least tern nesting season. Based on Schramm (1994).

Pallid Sturgeon

Consisting of only a few collection records, the historical population baseline of PS in the LMR is unknown. Attempts to determine the population status were implemented in 2001 (see account under **Historical and Current Species Baselines in the LMR**, above). Since that time, evidence of recruitment has been documented and the number of individual PS records has increased proportionately with collecting effort. The identification of the LMR PS population trend (i.e., increasing/decreasing) will require several years of continued collection efforts and monitoring. Therefore, at this time, we cannot directly determine PS response to habitat changes induced by the CIP. However, current information indicates that the PS is widely distributed throughout the LMR and suggests the species is not uncommon.

As noted under **Factors Affecting the Species**, above, there is documentation of entrainment of shovelnose sturgeon by maintenance dredging in the MMR, suggesting the PS are also vulnerable. However, risk of entrainment in the LMR during dredging may be reduced due to the larger channel size, depth, and complexity compared to the MMR.

Channel maintenance dredging locations are mapped by the USACE and are considered relative to all locations where protected species occur and their seasonal habitat use. Spawning and habitats used by sturgeon early life history stages are protected by seasonal dredging restrictions. Telemetry monitoring of sonic-tagged PS in the LMR by USFWS/USGS has shown little use of crossovers by large size classes of PS, particularly in relation to use of other habitats in the LMR (e.g., Kroboth et al. 2013). PS telemetry relocations are also most frequently associated with water depths greater than 18 ft (Kroboth et al. 2013), and a recent study of fish depth distribution in the LMR reported minimum depth utilized by PS was 15 ft (Miranda & Killgore 2013), well below the authorized depth of the CIP.

Fat Pocketbook Mussel

The FPM was not historically known to survive in the active channel of the LMR. Recent collections of live individuals and fresh dead shells are primarily associated with secondary channels stabilized by notched dike fields. It is likely that the dike fields created conditions appropriate to the survival of FPM (P. Hartfield, U.S. Fish and Wildlife Service, Jackson, MS, pers. comm. 2012). Therefore, it appears that FPM has responded positively to the effects of the CIP. Construction and maintenance activities within dike fields and secondary channels are considered annually by USACE and partner agencies for potential negative effects to FPM and, if present, avoidance measures are identified (see below).

Avoidance and Minimization Components of the CIP

Potential effects of annual CIP channel construction and maintenance activities to PS, ILT, and FPM habitats, along with potential avoidance and minimization actions, are discussed and considered during annual partnership meetings hosted by Memphis and Vicksburg Districts (see **Management and Conservation Measures in the LMR**, below). Channel maintenance and restoration programs are currently focused on maintaining and enhancing overall channel habitat complexity through dike design and notching, restoration of secondary channels, and use of value engineering techniques such as hard points and chevrons that provide river stabilization and habitat benefits simultaneously. Priority species and their LMR habitats will continue to be quantified and monitored by USACE and other participating agencies. These data are used to determine the extent and significance of habitat modification to the priority species, quantify habitat benefits of creative engineering, project future habitat trends, identify habitat improvement opportunities, modify channel management programs as necessary, and monitor long-term habitat trends and responses.

PART VII: MANAGEMENT AND CONSERVATION MEASURES IN THE LMR

Long-term conservation of the three priority species, as well as other components of the LMR channel ecosystem, requires a multi-partner and multi-faceted scientific and engineering approach utilizing water and sediment to maintain and enhance aquatic habitat complexity, particularly associated with secondary channels and seasonally flooded/exposed habitats. Under the CIP, water and sediments are manipulated through channel engineering in order to maintain flood protection and a safe and efficient 9' deep x 300' wide navigation channel in the LMR from Cairo, Illinois, to Baton Rouge, Louisiana. Channel engineering, including channel structure maintenance, therefore, provides opportunities to utilize flows and sediments to improve or restore in-stream habitats outside of the navigation channel at little to no extra cost, and without impacting navigation activities or flood risk management. Dike notching and other river training structures have been successfully used for more than a decade for this purpose.

Several restoration projects unrelated to navigation, have been designed by the USACE, funded by state and Federal partners, and constructed by private contractors. Restoration projects constructed in recent years include weirs to prevent dewatering of floodplain oxbow lakes and channels, and retrofitted dike notches to restore flow through more than 40 miles of secondary channel habitat. This collaborative approach to using the CIP construction and maintenance projects as primary tools to manage and conserve the LMR ecosystem by the USACE, along with a better understanding, mapping, and avoidance of important habitat areas has resulted in significantly improved habitat for the PS, ILT, FPM, as well as numerous other channel-dependent species.

Partnerships

Key partnerships and guidelines have been developed over the last 10 years that facilitate development and implementation of this Conservation Plan. In 2001 the USACE-MVD LMR districts (New Orleans, Vicksburg, and Memphis), Southeast Region USFWS, and Lower Mississippi River Conservation Committee (LMRCC), which consists of 12 state natural resource management and environmental quality agencies, began conducting annual meetings to discuss LMR conservation issues and maintenance and construction projects. Key components of these Partnership meetings include updates on locations and habitat use by endangered species in the LMR channel, the identification and consideration of using environmental engineering principles in the design and construction of river training structures, and improving communication and coordination among partners for the benefit of all trust species in the LMR.

In 2002, the USACE introduced Environmental Operating Principles (EOP) to provide direction in all aspects of USACE activity for improved stewardship of land, water and air. EOP implementation guidelines were subsequently adopted to identify ways USACE missions can be integrated into environmental laws, values, and practices (ER 200-1-5). USACE-MVD has been applying EOPs into the CIP feature of the MR&T, as well as O&M activities in the LMR with varying success. Although the CIP is almost complete, remaining components, as well as on-going and future O&M activities provide opportunities to cost-effectively utilize EOPs to improve ecosystem responses to the programs that have affected channel habitat quantity and quality in the LMR. Annually, the USACE invites state and Federal natural resource biologists familiar with river-dependent species, multiple-use management of the LMR, and commercial navigation to meet and review proposed CIP actions for the year as well as for out years, and

identify conservation actions that can be incorporated into USACE channel maintenance activities. USACE has developed and periodically updates a Mississippi River Channel Improvement Master Plan which shows constructed and proposed channel training features, as well as environmental improvement features, and priority species locations.

The USACE has developed resources and information vital to strategic management of the LMR ecosystem. Aquatic and terrestrial habitats have been mapped within the 2.8 million-acre LMR leveed floodplain ecosystem. Aquatic habitat maps of the river's channel for 1880, 1915, and for ten-year intervals from the 1930s to the 1990s have been completed and are being used to assess historic habitat trends, conduct habitat spatial analyses, and evaluate project effects on Federally endangered species as well as other aquatic resources. Terrestrial habitat and land cover maps prepared using 1982 and 1992 data have been used to delineate jurisdictional wetlands, plan levee construction to avoid and minimize adverse environmental impacts, and maximize beneficial conservation effects. In addition, MVD investigations under the LMREP have been conducted on fish and wildlife populations and habitat values of levee borrow pits, effects of in-channel stone dikes, and articulated concrete mattress revetments. In 2001, the MVD initiated informal consultation with the USFWS under section 7(a)(1) of the Endangered Species Act to use LMREP designs and additional measures to conserve and manage listed species associated with the LMR navigation channel.

In 2000 the LMRCC developed an Aquatic Resource Management Plan (ARMP) for the 954 river-mile long LMR reach (http://www.lmrcc.org/ARMPstrategies.pdf)**.** The ARMP provided a 10-year operational plan to address several factors adversely affecting wetland-dependent natural resources in the LMR active floodplain and backwater areas. As mentioned previously, the Partnership conducted the Mississippi River Conservation Initiative (MRCI) during 2001–2004, which consisted of a series of planning meetings in the six LMRCC-member states (AR, KY, LA, MS, MO, and TN) that were designed to identify specific aquatic habitat restoration and public access opportunities (http://www.lmrcc.org/MRCI.htm). The MRCI was a landscape-scale effort that ultimately resulted in six state-specific lists consisting of 239 potential projects. In 2006, the LMRCC, under the auspices of the Partnership, began compiling the MRCI projects into a landscape-scale plan – Restoring America's Greatest River (RAGR). The RAGR plan comprises the implementation phase of the Partnership's five-year planning effort to rehabilitate the LMR leveed floodplain ecosystem (http://www.lmrcc.org/). Working cooperatively with the Partnership, the LMRCC has developed a comprehensive Geographic Information System comprised of spatial databases covering the LMR ecosystem and the Mississippi Alluvial Valley to support the implementation of the MRCI. Data holdings include vector files of roads, hydrology, river training features (dikes, revetments, levees, ports, etc.), public lands boundaries, satellite imagery, digital orthophotos, low water video, and raster data including soils, land cover/land use, Digital Elevation Models, and bathymetry. These projects raise the habitat and environmental baseline of priority species, offsetting and mitigating actions which may be essential to flood risk management and the maintenance and safety of the LMR commercial navigation channel.

Since 2005, USACE has collaborated with LMRCC and other partners to: 1) conduct synoptic studies of PS population status and habitat restoration benefits; 2) obtain geo-referenced video during low water periods to evaluate status of river training structures, and to determine habitat quality in secondary channels and other areas of the LMR; 3) quantify long-term changes in depth, volume, and status of secondary channels in the LMR; 4) begin studies of

gravel bars used by sturgeon and other riverine species as spawning sites; and 5) continue planning restoration projects. Information derived from these efforts is shared annually at the lower basin pallid sturgeon recovery meeting and the channel improvement meetings sponsored by the Memphis and Vicksburg Districts. Most recently, the USACE is working with partners to execute the Lower Mississippi River Resource Assessment (LMRRA).

The LMRRA was authorized in WRDA 2000, Sec. 402, and funding was initiated in FY09. The reconnaissance level report was approved March 5, 2010. The purpose of the study is to develop recommendations for: 1) the collection, availability, and use of information needed for river-related management; 2) the planning, construction, and evaluation of potential restoration, protection, and enhancement measures to meet identified habitat needs; and 3) potential projects to meet identified river access and recreation needs. The Nature Conservancy (TNC), along with LMRCC and other partners, including National Audubon Society, Delta F.A.R.M., and the American Land Conservancy, have joined this effort as cost-share partners on a feasibility level watershed study with the signing of the USACE – TNC cost share on January 11, 2012.

These partnerships and actions have provided opportunities to develop, test, and implement engineering modifications that fulfill USACE missions while simultaneously protecting and enhancing channel habitat values.

Conceptual Model

The USFWS now considers the USACE partnership and engineering process outlined above as the primary strategic approach to maintain river channel habitat values in the LMR, as well as for the management and recovery of listed species associated with the channel (USFWS 2012a). This strategic approach can be modeled as follows:

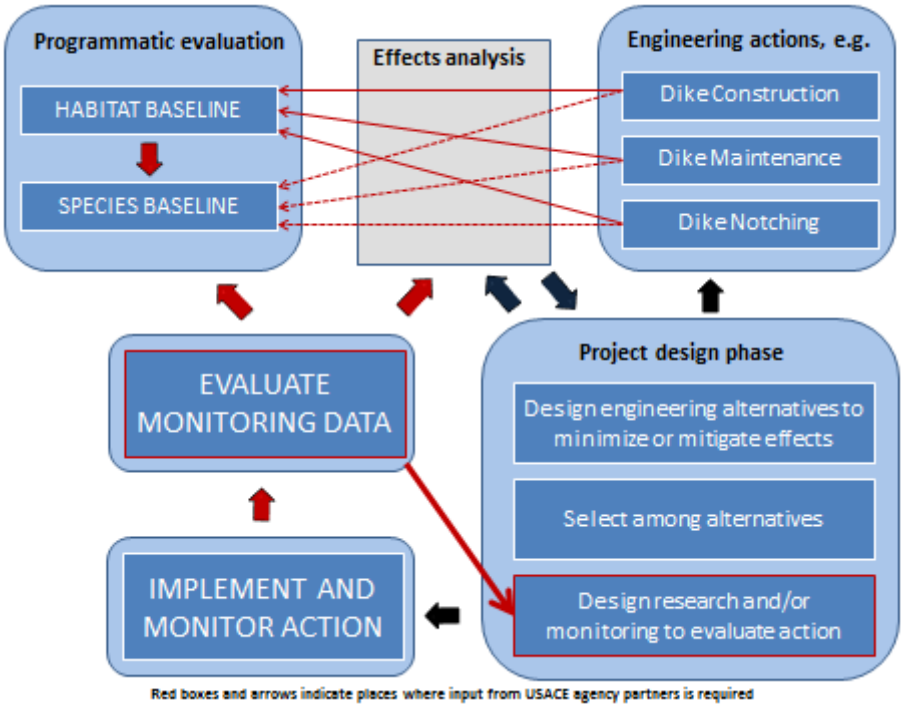

Figure VII-1. Conceptual model employing the CIP as for conservation and management of CIP Trust resources.

Conservation Plan Outline

The goal of this USACE-MVD conservation plan is to maintain the CIP while implementing or improving appropriate habitat conditions necessary for robust, resilient, and self-sustaining populations of ILT, PS, and FPM in the LMR. The objectives of this conservation plan are to utilize reasonable, prudent, and cost-effective channel maintenance and management practices to maintain and improve LMR channel habitat values for listed species and other native species.

The USACE-MVD and LMR Districts have identified the following strategies and actions to minimize adverse effects of the CIP, and to mitigate for past and potential future loss of LMR channel habitat quantity and complexity. These strategies and actions have been implemented, and tested for more than a decade under the channel ecosystem management partnership described above. Herein, the USACE-MVD and LMR Districts incorporate the following strategies and actions as Standard Operating Procedures and Best Management Practices under the CIP to conserve the endangered species associated with the LMR channel, as authorized and required under section 7(a)(1) of the Endangered Species Act . This conservation plan also complies with procedures and mandates under the USACE Environmental Operation Principles, the Civil Works Ecosystem Restoration Policy (USACE ER 1165-2-501), and Executive Order 13186 under the Migratory Bird Treaty Act.

Agency conservation programs developed under section 7(a)(1) of the Endangered Species Act are intended to assist Federal agencies and their potential partners in planning and implementing actions to protect and recover endangered or threatened species affected by the agencies activities. These conservation measures are a guide for meeting the goal and objective outlined above, and do not obligate any party, including the USACE to undertake specific actions at specific times. Implementation of the actions outlined below is contingent upon opportunity and annual appropriations and other budgetary constraints.

Strategy 1: Avoid adverse impacts directly associated with CIP engineering practices.

Actions:

a. <u>Comply with seasonal restrictions for construction when appropriate and/or possible</u>. Seasonal restrictions, or "windows," have been or may be established by state and Federal resource agencies to minimize nesting, spawning, or juvenile disturbance during all construction and maintenance activities. Currently, construction is prohibited from 1 April to 1 August on the LMR, a 5-month window. As new information is developed, these restrictions may be modified to reduce impacts on construction activities while protecting endangered species and their habitats. However, any changes to these seasonal restrictions could potentially impact the navigation mission of the CIP and will be carefully considered by all agencies involved.

b. <u>Avoid closure of secondary channels</u>. Loss of secondary channel habitat, and decline of endangered species habitat value, has occurred through the construction of secondary channel closure structures under the CIP. In recent years, alternatives such as strategic dike placement, chevrons, etc. have been successfully used in place of closure structures to maintain appropriate depth and width of the navigation channel.

c. Avoid impacts of dikes on gravel bars. Gravel bars are typically found at the upstream reach of islands and near crossings where water depth is shallow and dikes are required to maintain the navigation channel. Efforts are underway to identify established gravel bars and avoid construction activities that may result in accretion of sand over well-developed gravel substrates. Notching existing dikes impacting gravel substrates has also been targeted.

Strategy 2: Develop and implement channel construction and maintenance operation guidelines that conserve and restore LMR habitat for all three species, are subject to adaptive management, and can and will be continued should the species become fully recovered.

Actions:

a. Identify and implement dike construction and maintenance designs that maximize habitat complexity. Dike notching is the primary mechanism to increase habitat complexity. Most ILT colonies on the LMR are associated with dike fields, which create higher sandbars with less exposure to flooding during the summer nesting season. Notches are created by removing rock toward the landward end during maintenance work on an existing dike or by leaving an open, low section when a new dike is built (Guntren et al. 2012). Water flowing through the notch scours substrates below the dike increasing bathymetric diversity and allowing flow to isolate nesting sandbars through most of the nesting season. Dike notching and other alternative designs of river training structures (e.g., round points, chevrons, off-bankline revetment, as described by USACE (2006) and Pokrefke (2012), that increase habitat diversity and/or reduce impacts to endangered species and other native fauna will only be considered when there is minimal effect on the purpose and intent of the authorized project (i.e., navigation/flood risk reduction).

b. Restore connectivity to the main channel whenever possible. Restoration of secondary channels by notching or removing closure dikes, was identified as one of the top restoration priorities (Boysen et al. 2012) and an evaluation procedure has been developed to rank the habitat value of over 50 secondary channels for planning purposes (Killgore et al. 2012). In recent years, secondary channel restoration actions have required collaboration of multiple partners, and are expected to continue to do so.

c. Utilize chevrons instead of dikes where conditions are appropriate. Dike fields form large, homogenous sandbars that become exposed at moderate to low discharges. Chevrons will be constructed in selected areas to increase hydraulic diversity in homogenous sandbar habitat while maintaining appropriate flow conditions for navigation and bank protection.

d. Continue to create longitudinal grooves in ACM. Armoring riverbanks with ACM to protect the river channel is critical to both flood risk management and navigation. USACE has designed deep grooves in ACM to increase surface area, reduce surface current speed, and allow greater opportunity for attachment of invertebrates. This practice increases the biomass of invertebrates consumed by PS and by prey species for PS and ILT.

e. Utilize hardpoints in lieu of revetment where conditions allow. In some erosional areas, hardpoints are an alternative to ACM. They function to prevent bank erosion with less impact to natural riverbank. Hardpoints will be considered where practical.

f. Continue to strategically place large woody debris removed from banks during revetment construction or repair into the channel. Large woody debris removed from the bank during construction and maintenance activities will be strategically placed in the channel, to provide habitat for attached macroinvertebrates, as well as shelter for forage fish.

g. Minimize impacts of dredging. Dredging activities will avoid or minimize impacts on gravel bars, tributary mouths, and backwater habitats. The USACE will continue to abide by recommendations provided by the USFWS, including distance buffers and timing windows. Beneficial placement of dredged material will be utilized where appropriate and authorized.

Strategy 3: Develop cost-effective monitoring programs, as funding allows, to document habitat and species response to channel operations.

Actions:

a. Collaborate with USFWS and LMRCC to periodically monitor and measure habitat complexity and channel response to river training structures. Habitat complexity will be measured using existing capabilities including bathymetric surveys, Red Hen geo-referenced video, Lidar, ground truthing including gravel bar surveys, and aerial photography. GIS maps using River and Environmental Engineering GIS will be updated with new habitat information.

b. Utilize ILT and PS as surrogate species to monitor ecosystem response to management. Unless future information suggests otherwise, USACE will utilize these two endangered species as surrogates to document ecosystem function, quality, and response to USACE channel management, regardless of the species' future listing status under the ESA. FPM is not recommended as a surrogate species at this time due to limited data availability.

c. Conduct targeted monitoring and analysis of habitat utilization and preference of the three endangered species. Field surveys and telemetry will be conducted to evaluate habitat use of listed species and their responses to USACE construction and maintenance activities in the LMR.

d. Collaborate with USFWS to develop and implement a more statistically rigorous monitoring program to track ILT population trends on the LMR. Over the next 1-2 years, the ERDC-EL will be coordinating with USFWS, ABC, and the USGS to develop a range-wide monitoring program for the ILT, which will serve to (1) streamline and standardize existing monitoring techniques, and (2) provide a robust means of assessing range-wide population status into the future. Ideally, the monitoring protocol will rely upon sub-sampling rather than complete counts of adults throughout the range. If the ILT is delisted, monitoring on the LMR will be part of a required range-wide post-delisting monitoring plan.

e. Monitor population size and trends of PS in the LMR. Periodic monitoring of PS populations will continue using standardized collection methodologies. Key population attributes, including young-of-year survival, recruitment, adult survival, and density, will be evaluated using Population Viability Analysis models. Population size and trends will be compared among southern, middle, and upper reaches of the LMR. Information will be shared with partners at annual meetings and used to evaluate and modify conservation actions.

f. Conduct periodic surveys for presence/absence of FPM. Densities of FPM are naturally low in LMR, and there are no historical occurrence records. Therefore, measurements of population size or trends are currently not practical. However, low-water surveys of FPM in proposed or existing construction sites in main and side channel habitats should be conducted to evaluate presence/absence as budget and authority allows.

Strategy 4: Share restoration, research, and monitoring responsibilities and costs by maintaining strong partnerships with other Federal and state agencies and NGOs.

Actions:

a. Continue to sponsor annual meetings with partners to discuss and implement Actions 1 and 2 as part of regular program and project efforts.

b. Continue to work with LMRCC, The Nature Conservancy, and other partners to share restoration and funding responsibilities as budget and authority allow.

c. Promote the Lower Mississippi Resource Assessment as a means to identify and implement conservation and restoration measures.

The conceptual model (Figure VII-1) and objectives and actions outlined above have been developed in consultation with USFWS to comply with the ESA section 7(a)(1) statutory requirements to utilize USACE authorities to establish and carry out programs for the conservation of endangered species associated with CIP river operations, and for management and restoration activities to mitigate for impacts on listed species caused by river operations. They also comply with the intent and directives outlined under the USACE Environmental Operating Principles, and the Civil Works Ecosystem Restoration Policy (ER 1165-2-501), and support the conservation intent of EO 13186 Responsibilities of Federal Agencies to Protect Migratory Birds.

Implementation

Implementation of the tasks identified above by USACE-MVD and districts will commence immediately. In fact, all of these actions have been at least partially implemented for more than a decade, and many have become standard operating procedure by USACE-MVD. For example, to date almost 30% (230) of the dikes in the LMR (774) have been constructed or retrofitted with notches to increase channel border and seasonally flooded habitat diversity. More are in the planning process. Additionally, collaborative restoration projects between the USACE-MVD, LMRCC, and USFWS have cost-efficiently rehabilitated nine secondary

channels. Combined, these projects have restored flow to almost 40 miles of in-channel habitat and enhanced hundreds of acres of seasonally flooded habitats. These projects have shown no negative effect to the USACE's primary missions of flood damage reduction and provision of a safe, stable commercial navigation channel. Seasonal work windows are employed by USACE contractors, and are conditions in permits issued by USACE in the LMR. USACE-MVD has conducted analyses of secondary channels and completed a comprehensive secondary channel assessment (Williams & Clouse 2003; Guntren et al. 2012) that will guide decisions on future restoration sites. To date, seven chevrons and 247 hard points have been constructed, resulting in preservation of several miles of natural bank habitat. Limited research (and extensive monitoring) by USACE-ERDC, USFWS, USGS, and other partners on ILT, PS, and FPM has been conducted for more than a decade, and is on-going. Research funding has been provided by USACE-MVD, USACE districts, USFWS, USGS, Arkansas Game and Fish Commission, and others. Geomorphic and species research information is shared with all partners at annual meetings conducted by and at the LMR districts.

Elements of Adaptive Management

Adaptive management is a collaborative, multidisciplinary approach which treats actions and policies as testable hypotheses from which learning derives, which in turn provides the basis for changes in subsequent actions and policies (Stankey et al. 2005). Developing a *sensu stricto* adaptive management program for the three listed species relative to the CIP is not a realistic option for many reasons. These include: 1) lack of basic life history and habitat information for PS and FPM, 2) a lack of dedicated funding for research and monitoring, 3) practical constraints due to maintaining public safety and infrastructure integrity, 4) high levels of uncertainty in predicting or measuring species responses, 5) high levels of uncertainty in predicting or measuring local channel response, and 6) the duration of the management program.

The strategies and actions outlined above, however, provide for incorporating many useful elements of adaptive management into the CIP. Information gathered through channel monitoring and priority species research and monitoring has been used to modify/improve river engineering and other river regulation activities to avoid or minimize impacts to listed species and improve their habitat and population baselines in the LMR (see **Conceptual Model**, above). For example, 1) large gravel bars have been assigned a high priority for research and protection because PS larvae have been consistently collected below them and they are assumed to function as spawning substrates; 2) telemetry results are being used to provide insight into the possible effects of timing and location of channel maintenance activities on PS habitat use; 3) ILT nesting survey data have been used in the dike maintenance program to protect and improve nesting sites; 4) identification of secondary channels occupied by FPM has been used to modify in-channel and levee construction projects and improve methods to avoid/reduce impact to the species; and 5) agencies and NGOs are collaborating in GIS documentation of species records, existing engineered structures, and engineering modifications to benefit trust species and ecosystem complexity. New information is, and will continue to be considered during annual meetings between cooperating partners and agencies. At these meetings, data gaps, needs, engineering designs, and monitoring plans, all elements of adaptive management, are collaboratively identified, prioritized, and modified if necessary.

This collaborative and adaptive approach to management and conservation of the LMR has cost-effectively and significantly improved the scientific knowledge base of the three

endangered species; improved LMR habitats for them and numerous other game and nongame species; and provided substantial savings of conservation and channel maintenance funding. Continued interagency trust and cooperation are integral to continuing and fully implementing the USACE-MVD conservation plan, and to ultimately achieving the conservation goals of all agencies involved in the Partnership.

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Additional Proposal Information

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AGFC LMRRA support letter.pdf

Jeff Crow
Director

Caroline Cone
Chief of Staff and Deputy Director

Chris Colclasure
Assistant Deputy Director

Pat Fitts
Assistant Deputy Director

Arkansas Game and Fish Commission

August 8, 2017

Ms. Lisa Kiefel
Planning and Policy Division
USACE – Headquarters
441 G St. N.W.
Washington, D.C. 20314

Dear Ms. Kiefel:

The Arkansas Game & Fish Commission (AGFC) supports the Feasibility Study of initiating key recommendations from the Lower Mississippi River Resource Assessment to 1) establish a water quality monitoring program in the Lower Mississippi River and 2) conduct eight conservation reach habitat restoration and recreation enhancement studies on the Lower Mississippi River. These actions will assure that the Lower Mississippi River continues to provide for people and the natural inhabitants of this nationally important river system.

AGFC was an active partner in the development of the Lower Mississippi River Resource Assessment (LMRRA) through submission of AGFC data layers, meeting attendance, and our membership in the U.S. Fish & Wildlife Service's Lower Mississippi River Conservation Committee (LMRCC). The AGFC supports the work of the Lower Mississippi River partners in addressing the needs and opportunities identified by the LMRRA.

The LMRCC has been working towards balanced river management since 1994. As a LMRCC member AGFC supports the work proposed in this feasibility study. The LMRCC water quality agencies produced a report in 2014 that detailed current water quality monitoring in the Lower Mississippi River and noted that a larger more concerted effort was needed. Additionally, the LMRCC has been conducting habitat restoration projects on the Lower Mississippi River since 2006 and has demonstrated these efforts can be complementary to traditional river management such as navigation and flood risk management.

There is an opportunity to move toward an improved Lower Mississippi River that serves our needs and provides essential river health for the diverse species that reside or migrate through the Lower Mississippi River. Building from past planning activities included in LMRCC's Restoring America's Greatest River plan and the Lower Mississippi River Resource Assessment, partners will prepare a Feasibility Study designed to implement priority restoration projects and establish sequencing for project implementation. At the same time, the fundamentals of establishing a water quality monitoring program will be addressed with an end product that is ready for implementation. Water quality information is vital for managing the ecological health of the river but also provides valuable information for flood risk management and navigation.

2 Natural Resources Drive • Little Rock, AR 72205 • www.agfc.com
Phone (800) 364-4263 • (501) 223-6300 • Fax (501) 223-6448

The Arkansas Game and Fish Commission's mission is to conserve and enhance Arkansas's fish and wildlife and their habitats while promoting sustainable use, public understanding and support.

AGFC will continue to work with our state and federal partners to develop and implement projects that protect and enhance the LMR's natural resources while increasing opportunities for public use. We would like to add our voice to the many partners that believe the Lower Mississippi River can be managed for flood risk management and navigation, in addition to ecosystem restoration and recreation. Please give this proposal your full consideration.

Sincerely,

Chris Colclasure
Assistant Deputy Director, AGFC

2 Natural Resources Drive • Little Rock, AR 72205 • www.agfc.com
Phone (800) 364-4263 • (501) 223-6300 • Fax (501) 223-6448

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Additional Proposal Information

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UMRBA letter supporting Lower Miss ecosystem feasibility study 8 8 2017.pdf

Upper
Mississippi River
Basin Association
ILLINOIS, IOWA, MINNESOTA, MISSOURI, WISCONSIN

August 8, 2017

Ms. Lisa Kiefel
Planning and Policy Division
U.S. Army Corps of Engineers, Headquarters
441 G Street NW
Washington, D.C. 20314

Dear Ms. Kiefel:

On behalf of the Upper Mississippi River Basin Association (UMRBA), I am writing to support the joint request of the Lower Mississippi River Conservation Committee and The Nature Conservancy that the U.S. Army Corps of Engineers employ a feasibility study to design a long term water quality monitoring program and make recommendations for habitat restoration on the Lower Mississippi River. UMRBA was central to a similar process in developing the 1981 Upper Mississippi River Master Plan and in subsequent strategic planning for the Upper Mississippi River Restoration (UMRR) program. Over the past 30 years, these efforts have paid tremendous dividends to the Upper Mississippi ecosystem and overall balanced, integrated management of the river system for all human uses. We have experienced first-hand that improvements to ecosystem health can result in substantial regional economic gains and can be accomplished alongside improvements to the commercial navigation system and flood protection.

We fully anticipate that a Lower Mississippi River ecological monitoring and habitat restoration program would offer similar successes in balanced, adaptive management of the river and would complement efforts on the Upper Mississippi. Federal management of the Mississippi River is mostly divided at the confluence of the Ohio River. However, river flow is inseparable as is its ecosystem. Habitat restored in the Upper Mississippi is directly connected to fish and wildlife populations in the Lower Mississippi and vice versa. Restoration in either area is beneficial to the other. In addition, we believe there would be valuable insights gained in having complementary water quality monitoring on the Upper and Lower Mississippi Rivers, particularly in understanding the interconnectedness of the entire Mississippi River main stem.

We appreciate the Corps' consideration of our request for a feasibility study to evaluate the potential for an integrated science and restoration program on the Lower Mississippi River. Please contact UMRBA staff at 651-224-2880 with any questions.

Sincerely,

Tim Hall,
UMRBA Board Chair

415 Hamm Building
408 St. Peter Street
St. Paul, Minnesota 55102
Phone: 651-224-2880
Fax: 651-223-5815
www.umrba.org

Other Non-Federal Sponsors Letter(s) of Support

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Feasibility Study Letter of Support from LMRCC 8-9-17.pdf

Arkansas Kentucky Louisiana Mississippi Missouri Tennessee

Lower Mississippi River Conservation Committee
6578 Dogwood View Parkway, Suite A
Jackson, Mississippi 39213
Telephone 601-321-1139

August 9, 2017

Ms. Lisa Kiefel
Planning and Policy Division
USACE – Headquarters
441 G St. N.W.
Washington, D.C. 20314

Dear Ms. Kiefel:

The Lower Mississippi River Conservation Committee (LMRCC) would like to express our support of the Feasibility Study of initiating key recommendations from the Lower Mississippi River Resource Assessment to: 1) Establish a water quality monitoring program in the Lower Mississippi River and 2) Conduct eight conservation reach habitat restoration and recreation enhancement studies on the Lower Mississippi River. The LMRCC has been working cooperatively on habitat restoration in the Lower Mississippi River since its inception in 1994 and this study would greatly enhance our collective efforts towards holistic management of the system.

The LMRCC is a partnership of the six states on the Lower Mississippi River – Arkansas, Kentucky, Louisiana, Mississippi, Missouri and Tennessee. We are comprised of each state's natural resource conservation and environmental quality agencies. The LMRCC water quality agencies produced a report in 2014 that detailed current water quality monitoring in the Lower Mississippi River and noted that a larger more concerted effort was needed. Additionally, the LMRCC has been conducting habitat restoration projects on the Lower Mississippi River since 2006 and has demonstrated these efforts can be complementary to traditional river management such as navigation and flood risk management.

There is an opportunity to move toward an improved Lower Mississippi River that serves the needs of communities along the river and provides essential river health for the diverse species that reside or migrate through the Lower Mississippi River. Building from past planning activities included in LMRCC's Restoring America's Greatest River plan and the Lower Mississippi River Resource Assessment, partners will prepare a Feasibility Study designed to implement priority restoration projects and establish sequencing for project implementation. At the same time, the fundamentals of establishing a water quality monitoring program will be addressed with an end-product that is ready for implementation. Water quality information is vital for managing the ecological health of the river but also provides valuable information for flood risk management and navigation.

We would like to add our voice to the many partners that believe the Lower Mississippi River can be and should be managed for multiple uses – navigation, flood risk management, natural resources and recreation. Please give this proposal your full consideration.

Sincerely,

Albert E. Hindrichs, Chair
Lower Mississippi River Conservation Committee

Map Document

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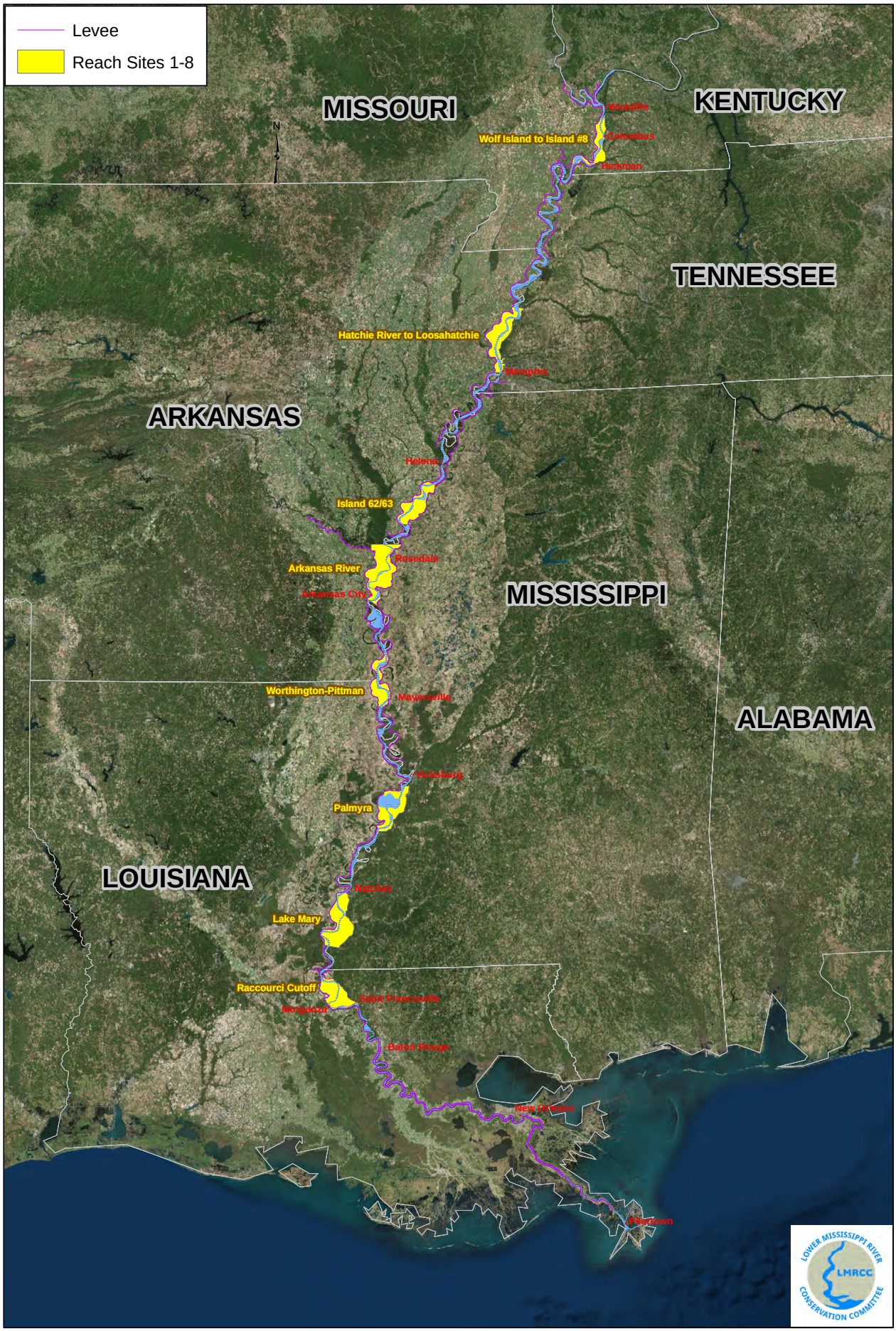
LMRRA Final Assessment Conservation Reaches Map.pdf

LMRRA Conservation Reach Study
Restoration Site Reaches 1-8



Prepared by LMRCC 06/Oct/2014

Additional Proposal Information

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Canalbargeltrofsup.pdf

CANAL BARGE

Move with confidence

July 31, 2017

Ms. Lisa Kiefel
Planning and Policy Division
USACE – Headquarters
441 G St. N.W.
Washington, D.C. 20314

Dear Ms. Kiefel:

I am writing in support of the Feasibility Study to initiate key recommendations from the Lower Mississippi River Resource Assessment to: 1) Establish a Water Quality Monitoring Program in the Lower Mississippi River and 2) Conduct planning and design at the eight Conservation Reach Habitat Restoration and Recreation Enhancement Studies on the Lower Mississippi River. This reasonable step will assure the Lower Mississippi River continues to provide for people and the natural inhabitants of the river system.

The Lower Mississippi River is a great river that receives flow from the Upper Mississippi, Ohio, Missouri, and Arkansas/Red Rivers, and guides that flow to the Gulf of Mexico. This river has experienced numerous great floods while also carrying $50 billion worth of agricultural products to export markets each year. The river is the economic and cultural driver for both the people who live along the banks and the entire nation.

For almost two centuries people have modified river dynamics to cope with floods and keep navigation traffic moving along the most extensive inland waterway system in the world. These changes to the river valley were necessary but over time they have degraded the natural forests, wetlands, channels, oxbows and bayous vital for plants, animals, and fish that historically thrived within the river basin. Today, we better understand the interactions between what people need to live with the river and how to balance those needs with the needs of a natural river system. There is an opportunity to move toward an improved Lower Mississippi River that serves our needs and provides essential river health for the diverse species that reside or migrate through the Lower Mississippi River.

Building from past planning activities included in Restoring America's Greatest River plan and the Lower Mississippi River Resource Assessment, partners will prepare a Feasibility Study designed to implement priority restoration projects and establish sequencing for the projects that should follow. At the same time, the fundamentals of establishing a Water Quality Monitoring program will be addressed with an end-product that is ready for implementation.

835 Union Street • New Orleans, LA 70112 • Phone 504.581.2424 • Fax 504.584.1505

CANAL BARGE

Move with confidence

Water quality information is vital for managing the ecological health of the river but also provides valuable information for flood risk management and navigation.

We would like to add our voice to the many partners that believe the Lower Mississippi River can be managed for flood risk management, navigation, ecosystem restoration, and recreation.

Please give this proposal your full consideration.

Sincerely,

H. Merritt Lane, III
Canal Barge Company, Inc.

835 Union Street • New Orleans, LA 70112 • Phone 504.581.2424 • Fax 504.584.1505

Additional Proposal Information

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MO Letter of Support.pdf

MISSOURI DEPARTMENT OF CONSERVATION

Headquarters

2901 West Truman Boulevard, P.O. Box 180, Jefferson City, Missouri 65102-0180

Telephone: 573-751-4115 ▲ www.MissouriConservation.org

SARA PARKER PAULEY, Director

August 8, 2017

Ms. Lisa Kiefel
Planning and Policy Division
USACE – Headquarters
441 G St. N.W.
Washington, D.C. 20314

Dear Ms. Kiefel:

The Missouri Department of Conservation supports a feasibility study to initiate key recommendations from the Lower Mississippi River Resource Assessment (LMRRA) to establish a water quality monitoring program and to conduct habitat restoration and recreation enhancement studies on eight conservation reaches in the Lower Mississippi River. This will ensure the Lower Mississippi River continues to support quality fish and wildlife resources and associated recreation for the people of Missouri and other Lower Mississippi River states.

The Lower Mississippi River Conservation Committee (LMRCC) has been working towards balanced river management since 1994. As a LMRCC member state, the Missouri Department of Conservation supports the work proposed in the LMRRA. There is an opportunity to move toward an improved Lower Mississippi River that serves society's needs and provides essential habitats for the diverse species that depend upon the river.

We appreciate the opportunity to participate in the LMRRA and future studies, and we look forward to working with our federal, state, and non-governmental organizational partners to improve fish and wildlife resources and river related recreational opportunities on the Lower Mississippi River. Please give this proposal your full consideration.

Sincerely,

SARA PARKER PAULEY
DIRECTOR

COMMISSION

DON C. BEDELL
Sikeston

JAMES T. BLAIR, IV
St. Louis

MARILYNN J. BRADFORD
Jefferson City

DAVID W. MURPHY
Columbia

Additional Proposal Information

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LMRLetter of Support TDEC.pdf

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DIVISION OF WATER RESOURCES
WILLIAM R. SNODGRASS TN TOWER
312 ROSA L. PARKS AVE., 11TH FLOOR
NASHVILLE, TN 37243

August 9, 2017

Ms. Lisa Kiefel
Planning and Policy Division
USACE – Headquarters
441 G St. N.W.
Washington, D.C. 20314

Dear Ms. Kiefel:

I am writing in support of the Feasibility Study to initiate key recommendations from the Lower Mississippi River Resource Assessment to: 1) establish a water quality monitoring program in the Lower Mississippi River and 2) conduct eight conservation reach habitat restoration and recreation enhancement studies on the Lower Mississippi River. These steps will help to assure the Lower Mississippi River continues to provide for people and the natural inhabitants of the river system. The Lower Mississippi River receives flow from the Upper Mississippi, Ohio, Missouri, Arkansas and Red rivers and guides that flow to the Gulf of Mexico. The river is the economic and cultural driver for the people who live along its banks.

The Lower Mississippi River Conservation Committee (LMRCC) has been working toward balanced river management since 1994. As a LMRCC member state, the state of Tennessee supports the work proposed in this feasibility study. The LMRCC water quality agencies produced a report in 2014 that detailed current water quality monitoring in the Lower Mississippi River and noted that a larger more concerted effort was needed. Additionally, the LMRCC has been conducting habitat restoration projects on the Lower Mississippi River since 2006 and has demonstrated these efforts can be complementary to traditional river management such as navigation and flood risk management.

There is an opportunity to move toward an improved Lower Mississippi River that serves our needs and provides essential river health for the diverse species that reside or migrate through the river. Building from past planning activities included in LMRCC's Restoring America's Greatest River plan and the Lower Mississippi River Resource Assessment, partners will prepare a Feasibility Study designed to implement priority restoration projects and establish sequencing for project implementation. At the same time, the fundamentals of establishing a water quality monitoring program will be addressed with an end-product that is ready for implementation. Water quality information is vital for managing the ecological health of the river but also provides valuable information for flood risk management and navigation.

The Lower Mississippi River is vital to the economic vitality of our state, and is necessarily managed to mitigate flood risk to our communities. We believe the Lower Mississippi River can be managed for flood risk and navigation, in addition to ecosystem restoration and recreation and appreciate your evaluation of the LMRCC's proposal.

Sincerely,

Tisha Calabrese Benton
Director, Division of Water Resources

Additional Proposal Information

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CATLTRofSUPPORT.pdf

CATERPILLAR FOUNDATION
100 N. E. ADAMS STREET
PEORIA, ILLINOIS 61629-1480

July 31, 2017

Ms. Lisa Kiefel
Planning and Policy Division
USACE – Headquarters
441 G St. N.W.
Washington, D.C. 20314

Dear Ms. Kiefel:

We (who) support the Feasibility Study to initiating key recommendations from the Lower Mississippi River Resource Assessment to: 1) Establish a Water Quality Monitoring Program in the Lower Mississippi River and 2) Conduct eight conservation reach habitat restoration and recreation enhancement studies on the Lower Mississippi River. This reasonable step will assure the Lower Mississippi River continues to provide for people and the natural inhabitants of the river system.

The Lower Mississippi River is a great river that receives flow from the Upper Mississippi, Ohio, Missouri, Arkansas/Red Rivers and guides that flow to the Gulf of Mexico. This river has experienced numerous great floods while also carrying $50 B worth of agricultural products to export markets each year. The river is the economic and cultural driver for both the people who live along the banks and the entire nation.

For almost two centuries people have modified river dynamics to cope with floods and keep navigation traffic moving along the most extensive inland waterway system in the world. These changes to the river valley were necessary but over time they have degraded the natural forests, wetlands, channels, oxbows and bayous vital for plants, animals, fish that historically thrived within the river basin. Today, we better understand the interactions between what people need to live with the river and how to balance those needs with the needs of a natural river system.

There is an opportunity to move toward an improved Lower Mississippi River that serves our needs and provides essential river health for the diverse species that reside or migrate through the Lower Mississippi River. Building from past planning activities included in Restoring America's Greatest River plan and the Lower Mississippi River Resource Assessment, partners will prepare a Feasibility Study designed to implement priority restoration projects and establish sequencing for the projects that should follow. At the same time, the fundamentals of establishing a Water Quality Monitoring program will be addressed with an end-product that is ready for implementation. Water quality information is vital for managing the ecological health of the river but also provides valuable information for flood risk management and navigation.

We would like to add our voice to the many partners that believe the Lower Mississippi River can be managed for flood risk management, navigation plus ecosystem restoration and recreation. Please give this proposal your full consideration.

Salutations,

Jennifer Zammuto, Chief Operations Officer
Caterpillar Foundation

Additional Proposal Information

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LMRCC_WQ_FINAL_Sept2014.pdf

Summary of Available Water Quality Assessments of the Lower Mississippi River

Lower Mississippi River Conservation Committee
Contributor: Paul Davis

September 2014

Lower Mississippi River Conservation Committee Member Agencies:
Arkansas Department of Environmental Quality
Arkansas Game and Fish Commission
Kentucky Department for Environmental Protection
Kentucky Department of Fish and Wildlife Resources
Louisiana Department of Environmental Quality
Louisiana Department of Wildlife and Fisheries
Mississippi Department of Environmental Quality
Mississippi Department of Wildlife, Fisheries and Parks
Missouri Department of Conservation
Missouri Department of Natural Resources
Tennessee Department of Environment and Conservation
Tennessee Wildlife Resources Agency

1 - Executive Summary

The Lower Mississippi River Conservation Committee (LMRCC) is a coalition of natural resource and environmental quality agencies from the six lower river states along with federal cooperating agencies and committed non-governmental organizations. The U.S. Fish and Wildlife Service provides a coordinator and support. The LMRCC's mission is to "Promote the restoration and wise use of the natural resources of the Lower Mississippi River through cooperative efforts involving planning, management, information sharing, public education, advocacy and research." Understanding the water quality condition of the river and the support of beneficial uses is fundamental to that mission. Where uses are threatened or not achieved, resource managers need to know the causes so protection and/or restoration measures can be planned and implemented. Critical to protection and restoration efforts is the need to benchmark and track the chemical, biological, bacteriological and physical properties of the river, including sediments, using robust measures of ecosystem health. Documenting the availability of water quality assessment data and information is the focus of this summary report.

Each of the six lower river states has authority to set water quality standards and conduct water quality assessments. Each state has their own water quality standards applicable to the Mississippi River and has included assessments of the river in their assessment reports.

The LMRCC states employ various methods to assess the river's water quality and support of beneficial uses. The bases for assessments include, but are not limited to: the use of water quality monitoring data, fish tissue data and associated advisories, dredging data, and spill data. In general, availability and use of water quality monitoring data is limited.

The LMRCC recommends the dedication of additional resources to the collection of data sets used for water quality assessments of the Mississippi River. Additionally, these assessments must have clear and well-defined objectives. The LMRCC, however, understands the resource challenges of each state and further recommends efforts be focused on leveraging resources. Through production of this Lower Mississippi River water quality assessment summary, the LMRCC has provided a starting point for states to use in understanding data availabilities and gaps.

2 - Introduction

The Mississippi River is this country's defining inland hydrologic feature. It borders on 10 states and drains parts of 31 states and two Canadian provinces. Included in the river's drainage basin are more than 72 million residents, a wide range of industry, and some of the most productive agricultural lands anywhere. Beyond that, the Mississippi region is widely recognized not only for wildlife and outdoor recreation, but also as the inspiration for literature, art and music. The river's importance to our nation cannot be overstated.

The term "Lower Mississippi River" refers most commonly to the free-flowing portion of the river downstream from its confluence with the Ohio River, at Cairo, Illinois, 954 river miles from the Gulf of Mexico. That's how "Lower Mississippi River" and "lower river" are used here.

In 1996, two years after its formation, LMRCC published as its December newsletter a "Water Quality Issue" which included a state-by-state summary of threats facing the river and a discussion of state monitoring programs and results. That document is available upon request from LMRCC.

This project was undertaken to present the condition of the Lower Mississippi River as reported under Title 3 of the Clean Water Act by the six lower river states. State assessments include the Mississippi River itself and major tributaries at their junction with the river. Additionally, information on water quality assessments of other agencies is presented in summary form.

3 - The Processes of Water Quality Assessment

3.1 Water Quality Standards

The Federal Water Pollution Control Act, more commonly referred to as the "Clean Water Act," requires states, subject to EPA oversight, to take the primary role both in setting goals for the nation's waters and in assessing waters to determine the extent to which those goals are achieved. These goals, called "water quality standards," are based on the beneficial uses of the waters to be protected, such as public water supply, protection of fish and aquatic life, navigation and use by wildlife, recreation, agriculture and industry. States vary in how they describe and assign uses to their waters, and no two of the lower river states are exactly alike.

For each use, states adopt criteria—numeric or narrative descriptors of the chemical, physical, biological, or bacteriological conditions—that good science finds necessary to protect the waters so classified. "Antidegradation," the third part of water quality standards, describes how uses are to be protected from activities that would lower the quality of waters, with special protection for certain waters.

States are required to review, and revise as needed, their standards through an open process at least every three years, and revisions to those standards are then subject to EPA review. Challenges by EPA or by other interested parties to state water quality standards are not uncommon.

The following identifies for each lower river state the body responsible for adoption of water quality standards and the website where its standards may be found:

3.1.1 Arkansas – The Arkansas Pollution Control and Ecology Commission sets water quality standards. http://www.adeq.state.ar.us/commission/default.htm

3.1.2 Kentucky – Standards are proposed by the Energy and Environment Cabinet, subject to legislative approval. http://www.lrc.ky.gov/kar/401/010/031.htm
Note: Kentucky has designated the Mississippi River as Outstanding State Resource Water (OSRW) from river mile 942.3 to 947.0 and from 957.1 to 959.1 because of the presence of federally listed species, *Scaphirhynchus albus* (Pallid Sturgeon) and *Potamilus capax* (Fat Pocketbook Pearly Mussel).

3.1.3 Louisiana – Standards are adopted by the Louisiana Department of Environmental Quality, subject to legislative approval.
http://www.deq.louisiana.gov/portal/Portals/0/planning/regs/title33/33v09-201211.pdf

3.1.4 Mississippi – Standards are adopted by the Mississippi Commission on Environmental Quality.
http://www.deq.state.ms.us/mdeq.nsf/pdf/legal_11Miss.Admin.CodePt.6Ch.2./$File/11%20Miss.%20Admin.%20Code%20Pt.%206%20Ch.%202..pdf?OpenElement

3.1.5 Missouri - Standards are proposed by the Department of Natural Resources and adopted by the Missouri Clean Water Commission.
http://www.sos.mo.gov/adrules/csr/current/10csr/10c20-7a.pdf

3.1.6 Tennessee – Standards are promulgated by the Board of Water Quality, Oil and Gas.
http://www.tn.gov/sos/rules/1200/1200-04/1200-04-03.20110531.pdf and
http://tn.gov/sos/rules/1200/1200-04/1200-04-04.pdf

3.2 Water Quality Assessment

"Assessment" is the process of monitoring waters and determining their quality based on comparing chemical, physical, bacteriological and/or biological measurements to water quality standards. When the criteria for a particular use are met, that water body is assessed as "supportive" of that classified use. When the criteria are not met for a specified magnitude, duration and/or frequency, the use is said to be "impaired" or "not being supported." Waters can support some uses while being impaired for others; for example, a stream may not have sufficient oxygen for fish, but may be perfectly suitable for swimming.

The Clean Water Act requires that states assess and report the quality of their waters in a document called by its section number in the law: 305(b). A separate part, Section 303(d), requires states to develop, through an open process, a list of all their waters that have been assessed as not fully supporting classified uses. Both reports are required on even-numbered years. Arkansas, Kentucky, Louisiana and Missouri each combine their impaired waters lists, the 303(d) reports, with their 305(b) reports to create "Integrated Reports."

Those state assessment reports can be seen at the following websites:

3.2.1 Arkansas
http://www.adeq.state.ar.us/water/pdfs/draft_2012_integrated_water_quality_monitoring_and_assessment_report.pdf

3.2.2 Kentucky
http://water.ky.gov/waterquality/Pages/IntegratedReport.aspx

3.2.3 Louisiana
http://www.deq.louisiana.gov/portal/DIVISIONS/WaterPermits/WaterQualityStandardsAssessment/WaterQualityInventorySection305b/2012IntegratedReport.aspx.

3.2.4 Mississippi
http://www.deq.state.ms.us/mdeq.nsf/page/fs_surfacewaterqualityassessments?opendocument
http://www.deq.state.ms.us/mdeq.nsf/page/twb_total_maximum_daily_load_section?opendocument

3.2.5 Missouri
http://www.dnr.mo.gov/env/wpp/waterquality/303d.htm

3.2.6 Tennessee
http://www.tn.gov/environment/water/docs/wpc/2012_305b.pdf
http://www.tn.gov/environment/water/docs/wpc/2014-draft-303d-list.pdf

3.3 Assessment Units

Water quality data and assessment status are indexed to reaches or sections of waters. On smaller streams it is common for a reach to begin or end at a convergence or a change in grade or riparian land use—anywhere stream conditions might be expected to change. On the Mississippi River, assessment units are typically defined by political boundaries and by hydrology and hydromodification, such as levees. In most instances, these are USGS hydrologic units.

Assessment units for the lower river states are as follows:

3.3.1 Arkansas– Arkansas reported 22 separate assessment units, in three hydrologic unit codes or "HUCs" following the hydrologic unit map developed by USGS.
(see http://water.usgs.gov/GIS/huc.html)

All segments have the same classified uses: Primary and Secondary Contact Recreation, Domestic, Industrial and Agricultural Water Supply, and Perennial Delta Fishery.

3.3.2 Kentucky – Kentucky's entire 66.6-mile section of the Mississippi River is in a single assessment segment, GNIS #517524-01. This section is classified for Warmwater Aquatic Habitat, Primary Contact Recreation and Secondary Contact Recreation.

Kentucky has assessment units for its three major tributaries at their junction with the Mississippi River. All are classified for Warmwater Aquatic Habitat, Primary Contact Recreation and Secondary Contact Recreation.

3.3.3 Louisiana - Louisiana has 14 subsegments or assessment units located along and in the Mississippi River basin in the state of Louisiana. All 14 subsegments are classified as Primary Contact Recreation and Secondary Contact Recreation. Thirteen are Fish and Wildlife Propagation Use, while one is Limited Aquatic Life and Wildlife Use. Three subsegments are Drinking Water Supply and one subsegment near the coast is classified as Oyster Propagation.

3.3.4 Mississippi – According to MS water quality standards, the Mississippi River is classified for Fish and Wildlife use and should be suitable for aquatic life use, fish consumption, and secondary contact recreation. The Mississippi Department of Environmental Quality does not have any current assessments on the Mississippi River because water quality data of sufficient quality and quantity do not exist to assess the designated uses. However, where data of sufficient quality and quantity exist, MDEQ does assess waters of the state according to the Clean Water Act Section 305(b) guidance. Waters that do not meet designated uses are added to the active Clean Water Act Section 303(d) List of Impaired Waters. Although MDEQ does not have any current assessments on the Mississippi River, there are available assessments on tributaries to the Mississippi River. These assessments are outlined below:

- Segment 950712: **Yazoo River** from MWS Boundary 9195 to Belzoni, MS. This segment was assessed as impaired for Fish Consumption and a TMDL was completed for DDT/Toxaphene.
- Segment 107811: **Big Black River** from Confluence with Bear Creek to confluence with Clear Creek. This segment was assessed as impaired for Aquatic Life Use. The causes of impairment were identified as Chemical Oxygen Demand, pH and Total Organic Carbon This segment is scheduled for TMDL development.
- Segment 602823: **Bayou Pierre** from Confluence with Storm Creek to Confluence with Unnamed Tributary to Bayou Pierre at MWS 6029 boundary . This segment was assessed as impaired for Aquatic Life Use. The cause of the impairment was identified as pH and this segment is scheduled for TMDL development.
- Segment 607812: **Homochitto River** from MWS 6074 boundary to confluence with Dry Creek. This segment was assessed as attaining Aquatic Life Use Support.

3.3.5 Missouri – Missouri has a single assessment unit of its section of the river, Waterbody Identification Number (WBID) 3152. The designated uses for this segment of the river are Protection of Warm Water Aquatic Life and Human Health – Fish Consumption, Drinking Water Supply, Industrial, Irrigations, Live Stock and Wildlife Watering, Secondary Contact Recreation, and Whole Body Contact Recreation - Level B. This information is located in Appendix H of Missouri's water quality standards (http://www.sos.mo.gov/adrules/csr/current/10csr/10c20-7a.pdf).
It is also available from on-line Water Quality Standards Searchable database (http://www.dnr.mo.gov/mocwis_public/waterQualityStandardsSearch.do).

3.3.6 Tennessee – Tennessee has five assessment units on the river itself as well as the assessment units for major tributaries Obion River, Hatchie River, Loosahatchie River, Wolf River, and McKellar Lake at their junction with the Mississippi. The Mississippi River units are, like Arkansas, based on USGS HUC accounting units.

All of Tennessee's assessment units on the Mississippi are classified for Livestock Watering and Wildlife, Irrigation, Recreation, and Fish and Aquatic Life. In addition, all except one are classified for Domestic Water Supply.

Tennessee has 5 major tributaries at their junction with the Mississippi River. All five of the tributaries at the junction are classified for Livestock Watering and Wildlife, Irrigation,

Recreation, and Fish and Aquatic Life. The Hatchie River is classified for Industrial Water Supply and Domestic Water Supply, in addition to those uses.

3.4 Sources of Data and Information Used in Assessments

In addition to data the states produce through their own monitoring programs, EPA regulations require that states assemble and evaluate existing and readily available data from other sources including federal, state and local government, academic institutions, non-governmental organizations, permittees, citizen groups—anyone who can contribute to what is known about the conditions of the state's waters. States' use of data from outside sources is conditional on documentation of accepted practices in all phases of monitoring (field instrumentation, sample collection, laboratory methods, data management and reporting) that produce the quality of data needed for assessments.

Some external sources of data generally considered by states may include:

- U.S. Army Corps of Engineers
- U.S. Geological Survey
- U.S. Environmental Protection Agency
- U.S. Forest Service
- National Park Service
- Ohio River Sanitation Commission (ORSANCO)
- Local government, sewer districts, utility districts
- NGOs and citizen groups

3.5 Water Quality Assessments and TMDLs

States' lists of impaired and threatened waters, the 303(d) lists, identify the suspected source(s) of impairment, if known, for each listing. For waters impaired by pollutants, such as chemicals, sewage or silt, states must develop recovery plans that allocate the allowable loading of pollutants to all the various sources in the watershed. These plans are called "Total Maximum Daily Loads" and once developed and approved by EPA they are the basis for limits that will apply to regulated discharges, such as wastewater treatment plants. TMDLs also establish targets for unregulated sources, such as agricultural runoff. Waters impaired by sources other than pollutants, such as impoundments or channel modifications, are not required to have TMDLs.

Three TMDLs have been developed for the lower river. In 2006, EPA approved Missouri's TMDL for chlordane and PCBs in the portion of the Mississippi River that borders 16 Missouri counties. This information can be found on Missouri's TMDL website:
http://dnr.mo.gov/env/wpp/tmdl/0001-1707-3152-mississippi-r-record.htm
Tennessee has a TMDL approved for chlordane, dioxin, and PCBs in the Mississippi River Watershed that was approved in 2008. The TMDL is at:
http://www.tn.gov/environment/water/docs/tmdl-epa-approved/mississippi_pcb.pdf
Louisiana has a TMDL for fecal coliform bacteria in several subsegments of the Lower Mississippi River and Passes. It was approved in 2010 and can be found at:
http://www.epa.gov/waters/tmdldocs/ms_riv_3fc_tmdlsfinal_mar28_2011.pdf

3.6 Public Advisories Concerning Recreational Contact or Fish Consumption

It has long been the role of government to protect public health by warning citizens of known risks. Concerning surface waters, public health and environmental protection agencies use information such as bacteriological and chemical monitoring data, fish tissue analysis, overflow and spill reports, and epidemiological studies to warn the public about risk that may be associated with water contact or ingestion, as well as from consumption of contaminated plants or animals from waters.

The lower river states vary considerably in their assignment of authority to issue water advisories. A summary for each of the lower river states follows:

3.6.1 Arkansas - Arkansas Health Department sets fish consumption advisories. There are no such advisories on that states' section of the Mississippi.

3.6.2 Kentucky - Those agencies involved in joint issuance of fish consumption advisories in Kentucky are the Division of Water, the Department for Public Health and the Department for Fish and Wildlife Resources. The Division of Water and the Department for Public Health jointly issue swimming advisories for Public Health. On the basis of mercury contamination, KY has issued a statewide fish consumption advisory (one meal per week for the sensitive group consisting of children and pregnant women or women of child bearing age). Although not based on any direct monitoring from the state's section of the Mississippi River, that water is included.

3.6.3 Louisiana – Louisiana uses a multi-agency group consisting of Agriculture and Forestry, Health and Hospitals, Wildlife and Fisheries, and Environmental Quality to establish advisories concerning fish consumption or primary/secondary contact. There are no advisories for Louisiana's part of the Mississippi.

3.6.4 Missouri – The Missouri Department of Health and Senior Services (MDHSS) has issued fish consumption advisories for the Mississippi River. The DHSS has issued a general statewide fish consumption advisory for mercury, stating consumption should be limited to one meal per month for largemouth bass, spotted bass, small mouth bass and walleye for sensitive populations (e.g. pregnant women, women of childbearing age, nursing mothers, and children younger than age 13). Additional MDHSS fish consumption advisories for both Mississippi and Missouri Rivers due to PCB's, chlordane, and mercury contamination are as follows:

- shovelnose sturgeon (all sizes, excluding eggs) should be limited to one meal per month
- sturgeon eggs should not be eaten at any time.
- Flathead, channel, and blue catfish (greater than 17 inches) should be limited to one meal per week.
- Common carp (greater than 21 inches) should be limited to one meal per week

There are no recreational advisories issued for Missouri's section of the river.

Annually, the DHSS, Missouri Department of Conservation, Missouri Department of Natural Resources, along with other agencies coordinate monitoring activities to evaluate the amount of

contaminants in Missouri sport-caught fish. The current fish consumption advisories for Mississippi River can be found at http://health.mo.gov/living/environment/fishadvisory/index.php.

3.6.5 Mississippi – Fish Consumption advisories are issued by the Mississippi Fish Advisory Task Force, made up of the Mississippi Department of Environmental Quality, the Mississippi Department of Health, the Mississippi Department of Wildlife Fisheries and Parks, and other stakeholders within the state. The Task Force has issued a regional consumption advisory for the Yazoo River Basin in the area known as the Delta, for legacy pesticides DDT and Toxaphene. There are no advisories issued by the task force on the Mississippi River in Mississippi. For more information on Mississippi Fish Consumption advisories, please refer to the website: Mississippi Fish Advisories (http://www.deq.state.ms.us/Mdeq.nsf/page/FS_Mississippi_Fish_Advisories?OpenDocument).

3.6.6 Tennessee – The Tennessee Department of Environment and Conservation has authority to issue advisories regarding recreational use, including non-commercial fishing, in the state's waters. There is an advisory for fish consumption from the Mississippi state line up to a point just below Meeman-Shelby State Park. This is based on chlordane, other organics and mercury. The Tennessee Wildlife Resources Agency regulates commercial fishing, and there is a ban on commercial fishing in this same water. The TDEC advisory also applies to the lower portion of the Memphis-area tributaries to the Mississippi: Loosahatchie River, Wolf River and McKellar Lake.

3.7 Limitations of Water Quality Assessments

This document uses the term "assessment" in referring to the finding by states of support or non-support of classified uses in their waters. As stated above, those are threshold determinations, meaning states report support, partial support or non-support based on water quality standards. The states vary in how they report the degree to which conditions are better or worse than the standard in the Clean Water Act assessments. Those interested in the condition of the river should consider not only the assessment status as reported but also the information underlying those assessments, as well as other available information in discussing the condition of the Lower Mississippi River.

4 - Summary of State Assessments

4.1 Arkansas – The Arkansas Department of Environmental Quality does not presently monitor the Mississippi River and no portion of the river in that state is considered to be assessed. Four stations were monitored years ago by the predecessor agency, the Arkansas Department of Pollution Control and Ecology, but the last of those sites was discontinued in April 1992.

The state does regular monitoring on major tributaries, Arkansas River (ARK0020), the St. Francis River (FRA0013), and the L'Anguille River, (FRA0010).

4.2 Kentucky – Kentucky has not monitored the Mississippi River in the past. Efforts are being made to establish an ambient station on the Mississippi River at Columbus-Belmont State Park in Hickman County.

Kentucky has assessed Mayfield Creek at its junction with the Mississippi River. Biological, bacteriological and water chemistry data at the station indicate that Mayfield Creek does not support the Warmwater Aquatic Habitat use because of other flow regime alterations and habitat conditions. Fish tissue has been collected in the lower portion of Bayou de Chien and it has been assessed as partially supporting the Fish Consumption use because of mercury levels in the collected fish. The lower portion of Obion Creek has been assessed as not supporting Warmwater Aquatic Habitat and Primary Contact Recreation uses because of sedimentation, habitat conditions, other flow regime alterations and *Escherichia coli*.

4.3 Louisiana – Louisiana has three routine active ambient water quality monitoring sites on the lower river and has historical data for other lower river ambient sites and special project monitoring sites. The Louisiana 303(d) list in the 2012 Integrated Report listed five subsegments within the Mississippi River Basin in Louisiana as impaired. These subsegments include 1) 070401 Mississippi River Passes-Head of Passes to Mouth of Passes, includes all passes in the birdfoot delta (Estuarine) for turbidity; 2) 070503 Capitol Lake for dissolved oxygen; 3) 070504 Monte Sano Bayou for lead, dissolved oxygen and fecal coliform; 4) 070505 Tunica Bayou for fecal coliform; and 5) 070601 Mississippi River coastal bays and gulf to 3-mile limit for fecal coliform.

4.4 Missouri –
The lower Mississippi River is not actively monitored nor included in Missouri's ambient water quality monitoring network. The ambient monitoring network does collect water quality data from St. Johns Ditch (a tributary of the Mississippi River) at Henderson Mound. Water quality data is collected from St. Johns Ditch for field measurements (including bacteria), nutrients (9 times per year), trace metals and major ions (3 times per year), total residue (6 times per year), and pesticides (6 times per year). In 2006, St. Johns Ditch was listed as impaired for bacteria due to rural nonpoint sources and urban runoff/storm sewers, and mercury in fish tissue due to atmospheric deposition.

Overall, there is a limited amount of water quality data for the mainstem of the Mississippi River for this lower reach. In 2002, Missouri listed the Mississippi River as impaired for PCBs and Chlordane in fish tissue. A TMDL was written and approved for this impairment in 2006. Since the 2002 listing, Missouri's assessment criteria have been updated. During the more recent assessment cycles, fish tissue data was obtained from the Tennessee Department of Environment and Conservation, Missouri Department of Conservation, and United States Environmental Protection Agency, Region 7. Chlordane (sum of isomers) and PCBs in fish tissue in the lower section of the lower Mississippi River were less than the "no consumption" advisory level that has been established by the MDHSS. Although the Missouri Department of Natural Resources has assessed the lower section of the Mississippi River as unimpaired by chlordane and PCB's in fish fillets, Missouri anglers should still follow the fish consumption advisories recommended by MDHSS.

4.5 Mississippi – The Mississippi Department of Environmental Quality assesses major tributaries, but not the river itself.~~.~~ Prior to 2006, limited assessments on the river were provided in Section 305(b) reports; however, MDEQ's 2006 Section 303(d) list explained that the agency considers the Mississippi River, and decisions concerning listing, delisting and TMDLs, to be at national scale, properly belonging to EPA Regions 4 and 6.

4.6 Tennessee – Historically, Tennessee conducted semiannual chemical and bacteriological monitoring near Memphis at River Mile 724.6. That monitoring ended in the late 1990s and water column chemistry was not the basis for a determination of impairment. The state's 2012 assessment reports its Recreation use to be impaired for all five units along the Mississippi based on fish tissue data. The state considers consumption of fish tissue to be part of the Recreation use, and in the past found some species contaminated by chlordane, dioxin (including 2,3,7,8 – TCDD), and PCBs in all sections of the river. The state attributes this condition to contaminated sediments. Additionally, in TN0801010001_1000, the state identified mercury from atmospheric deposition as a contaminant of fish tissue. Dredging impacts to habitat were listed as the cause of the Fish and Aquatic Life use being impaired in all five Mississippi River assessment units.

Tennessee's major tributaries are identified as having a number of impairments. At its junction with the Mississippi, the Obion River is impaired for Recreation by unknown sources of bacteria and for Fish and Aquatic Life due to habitat alteration and siltation from channelization and non-irrigated crop production. The Hatchie River is found fully supporting all uses. The Recreation use of each of the Memphis-area tributaries to the Mississippi (Loosahatchie River, Wolf River and McKellar Lake) was impaired by chlordane, dioxin (including 2,3,7,8-TCDD) and PCBs from contaminated sediments and mercury from atmospheric deposition. Recreation in the Wolf River and McKellar Lake was further impaired by bacteria from urban stormwater runoff plus sanitary sewer overflows in the case of McKellar Lake. The Fish and Aquatic Life use is impaired in the Loosahatchie River by phosphorous in urban stormwater and habitat alteration and siltation from channelization. In the Wolf River, that use is also impaired by those causes plus lead from historic hazardous waste sites. In McKellar Lake, the Fish and Aquatic Life use is impaired by nitrogen and oxygen deficit caused by urban stormwater runoff and by siltation from dredging.

5 - The Condition of the Lower Mississippi River

5.1 State Assessments

As the summaries above illustrate, the lower river states, when they assess the river, use a variety of mechanisms. While all states monitor and assess tributaries, five of the six states have no active ambient monitoring on the river itself. The sixth state, Louisiana, monitors the very lowest portion of the river.

Arkansas, Kentucky and Mississippi do not assess their portions of the river. Missouri's assessment document currently reports no impairment for the Lower Mississippi River. Louisiana's 303(d) list outlines impairments to passes, bayous and coastal areas. Tennessee reports its criteria for Recreation to be violated over its entire length by organics in fish tissue, with mercury adding to that in one assessment unit. Criteria for Fish and Aquatic Life are reported to be violated by dredging impacts on habitat.

5.2 National Research Council

The National Research Council (NRC) prepared a report in 2008 titled MISSISSIPPI RIVER WATER QUALITY AND THE CLEAN WATER ACT: Progress, Challenges and Opportunities, available at http://www.nap.edu/catalog.php?record_id=12051. The NRC report provides a comprehensive, including historical, review of river water quality, factors that affect water quality, and the evolution of the Clean Water Act and its impact on water quality programs affecting the river.

The NRC report suggests that data sets are lacking across the states to allow for a coordinated, comprehensive assessment of the river:

> "Although there are some important federally sponsored efforts in monitoring Mississippi River water quality—such as those conducted by the U.S. Army Corps of Engineers and the U.S. Geological Survey, especially on the upper river—there is no single water quality monitoring program or central water quality database for the entire length of the Mississippi. Thus, there are limited amounts of water quality and related biological and ecological data for the full length of the Mississippi River, especially the lower river. This limited amount of data inhibits evaluations of water quality problems along the river and into the Gulf of Mexico, which in turn inhibits efforts to develop, assess, and adjust water quality restoration activities. Moreover, the limited attention devoted to monitoring the river's water quality is not commensurate with the Mississippi River's exceptional socioeconomic, cultural, ecological, and historical value. The lack of a centralized Mississippi River water quality information system and data gathering program hinders effective implementation of the Clean Water Act and acts as a barrier to maintaining and improving water quality along the Mississippi River and into the northern Gulf of Mexico (p. 5)."

5.3 U. S. Environmental Protection Agency (EPA)

EPA does not collect any water quality samples on the Lower Mississippi River on a regular basis, but the EPA through the National Rivers and Stream Assessment Program (NRSA) funded limited monitoring activities, including some state participation, along the lower river to conduct a chemical, biological and ecological assessment in 2008. This sampling effort was the first multi-state monitoring along the lower river and was similar to an earlier assessment of the Upper Mississippi River (the area of the Mississippi River north of its junction with the Ohio River). The U.S. Geological Survey state water science centers (Arkansas and Louisiana), state departments of environmental quality and state wildlife and fisheries agencies collected the environmental samples and shipped them to EPA-approved laboratories. A draft report is available at: http://water.epa.gov/type/watersheds/monitoring/aquaticsurvey_index.cfm

5.4 U.S. Army Corps of Engineers

The Corps has limited historical water quality chemistry data for the Mississippi River. However, the Corps collects extensive suspended-sediment and water-discharge data for the Lower

Mississippi River. Primary suspended-sediment collection sites include the Mississippi River at Memphis, Vicksburg, and Tarbert Landing, the latter which has been monitored for more than 60 years. Suspended-sediment data is important for water quality assessments in that many of the chemicals of interest such as trace metals, phosphorus, organochlorine pesticides, and other hydrophobic organic compounds are concentrated on sediments. Suspended sediment also plays a key role in remediation of coastal land loss in Louisiana.

5.5 U.S. Geological Survey

The U.S. Geological Survey (USGS) has conducted numerous studies along the Lower Mississippi River and has operated a water-quality monitoring network along the Lower Mississippi River since 1973 as part of the National Stream Quality Accounting Network (NASQAN) Program. NASQAN operates twenty-six stations throughout the Mississippi drainage basin but only four stations along the Lower Mississippi River. One site is located in Mississippi and the other three are located in Louisiana. The four stations are the Lower Mississippi River at Vicksburg, MS River Mile 437 [(RM) Above Head of Passes (AHP)]; at St. Francisville, LA (RM 265 AHP); at Baton Rouge, LA (RM 230 AHP); and at Belle Chasse, LA (RM 74AHP). St. Francisville is the oldest site, being in continuous operation since 1973; Belle Chasse is the second-oldest site, dating back to 1977. Vicksburg and Baton Rouge are relatively new sites, established in 2000.

The NASQAN program samples from Minnesota to Louisiana, studying the impacts of different hydrologic events, such as floods and droughts, on water quality. Currently, NASQAN monitors major ions, nutrients, trace metals, dissolved organic carbon, mercury, herbicides, bacteria, discharge and suspended sediment. The USGS also operates real-time continuous monitoring gages at Vicksburg and Baton Rouge that include nitrate, dissolved oxygen, pH, specific conductance and water temperature measurements. Nutrients, especially nitrate and phosphorus, have been detected at elevated levels in the Lower Mississippi River NASQAN samples. Atrazine, a herbicide used extensively in corn production and lawn care, is one of the most commonly detected organic compounds in the Lower Mississippi River. Although atrazine is rarely detected above drinking water standards (an annual average of 3.0 ug/l based on quarterly samples), it occurs in a majority of the samples collected at the Lower Mississippi River NASQAN stations. Information about the NASQAN program is available at: http://water.usgs.gov/nasqan/.

The USGS also has conducted several water-quality studies of the entire Mississippi River, starting in Minnesota and extending south all the way to near its confluence with the Gulf of Mexico. Water chemistry and suspended sediment were collected using a Lagrangian sampling scheme (sampling the same slug of water from the beginning to the end of the sampling trip). This sampling approach allowed for the comparison of water quality conditions along the course of the river. The study was one of the first to identify caffeine concentrations in Mississippi River downstream of major metropolitan areas and atrazine as one of the most commonly detected organic compounds in the river. The report, U.S. Geological Survey Circular 1133, Contaminants in the Mississippi River, 1987-1992 is available online at: http://pubs.usgs.gov/circ/circ1133/. An additional study by the USGS Toxics substances in water program looked at pharmaceutical compounds in selected water bodies across the United States, including some on the Lower

Mississippi River (Mississippi River at St. Francisville: http://toxics.usgs.gov/pubs/FS-027-02/index.html and Water-quality data for pharmaceuticals, hormones, and other organic wastewater contaminants in U.S. streams, 1999-2000 USGS Open-File Report 02-94). These and other reports, data and maps can be accessed on the Internet at http://toxics.usgs.gov. Additional data collection efforts would be beneficial to understanding changes in water chemistry.

6 – Discussion and Recommendations

The above information outlines the processes states use for conducting water quality assessments including adopting standards, monitoring waters to determine quality based on those standards and developing and implementing TMDLs or other remedial actions, as necessary. It also provides a synopsis of water quality monitoring conducted by USGS, EPA, and the Corps and summarizes the NRC report on the condition of the Lower Mississippi River. It is clear from this information there is much variation in the degree to which water quality is monitored on the lower river. Resources are limited and therefore an effort to increase monitoring efforts must be developed collaboratively to best leverage those resources.

In summary, the LMRCC recommends additional resources be dedicated to the collection of data sets used for water quality assessments of the Mississippi River. However, due to limited resources, it is critical to identify key data sets that will provide a quality basis for further evaluation of the river including its tributaries, distributaries and the Gulf of Mexico. The matter of excess nutrients being delivered to the Gulf is one of national importance, receiving attention from federal and state agencies, tribes, academia, industry, non-governmental organizations and the public in general. Improved water quality monitoring of the Mississippi River will assist the Gulf Hypoxia Task Force in addition to the many other assessment and restoration efforts.

To lay the groundwork for planning additional data collection efforts, the LMRCC recommends initial efforts be focused on identifying core and essential data that will allow comprehensive and meaningful water quality evaluations of the river. The LMRCC recommends intensive literature reviews on large river water quality studies to provide a starting point for what data is most beneficial to large river evaluations.

Once beneficial data sets have been identified, a thorough data-gap analysis can be conducted. Based on the data-gap analysis, plans can be developed for data collection efforts. These plans should take the form of work plans that can be used to either request funding, or be modified as needed for submittal when funding requests-for-proposals become available. Plans should be written with chronologically logical tasks that have discernible deliverables, data quality objectives and estimated costs; these plans can be broken down as needed if available funding amounts cannot cover the entire cost of the data collection project.

Additional Proposal Information

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LA DEQ ltr of support.pdf

JOHN BEL EDWARDS
GOVERNOR

CHUCK CARR BROWN, PH.D.
SECRETARY

State of Louisiana

DEPARTMENT OF ENVIRONMENTAL QUALITY
OFFICE OF ENVIRONMENTAL ASSESSMENT

August 3, 2017

Ms. Lisa Kiefel
Planning and Policy Division
USACE – Headquarters
441 G St. N.W.
Washington, D.C. 20314

Dear Ms. Kiefel:

The Louisiana Department of Environmental Quality (LDEQ) supports the Feasibility Study of initiating key recommendations from the Lower Mississippi River Resource Assessment to: 1) Establish a water quality monitoring program in the Lower Mississippi River and 2) Conduct eight conservation reach habitat restoration and recreation enhancement studies on the Lower Mississippi River. This reasonable step will assure the Lower Mississippi River continues to provide for people and the natural inhabitants of the river system.

The Lower Mississippi River is a prodigious river, receiving flow from the Upper Mississippi, Ohio, Missouri and Arkansas rivers. Before discharging to the Gulf of Mexico through its distributary rivers, the Atchafalaya and mainstem Mississippi in Louisiana, the system is joined by the Red River; thus adding significant flow from parts of Louisiana, Texas, Oklahoma and New Mexico. This immense river system has experienced numerous great floods while also carrying $50 billion worth of agricultural products to export markets each year. The river is the economic and cultural driver for the people who live along its banks.

The Lower Mississippi River Conservation Committee (LMRCC) has been working towards balanced river management since 1994. As a LMRCC member state, the Louisiana Department of Environmental Quality supports the work proposed in this feasibility study. The LMRCC water quality agencies produced a report in 2014 that detailed current water quality monitoring in the Lower Mississippi River and noted that a larger, more concerted effort was needed. Additionally, the LMRCC has been conducting habitat restoration projects on the Lower Mississippi River since 2006 and has demonstrated these efforts can be complementary to traditional river management such as navigation and flood risk management.

There is an opportunity to move toward an improved Lower Mississippi River that serves our needs and still provides essential river health for the diverse species that reside or migrate through the Lower Mississippi River. Building from past planning activities included in LMRCC's *Restoring America's Greatest River* plan and the *Lower Mississippi River Resource Assessment*, partners will prepare a Feasibility Study designed to implement priority restoration projects and establish sequencing for project implementation. At the same time, the fundamentals of establishing a water quality monitoring program will be addressed with an end-product that is

ready for implementation. Water quality information is vital for managing the ecological health of the river but also provides valuable information for flood risk management and navigation.

The LDEQ would like to add our voice to the many partners that believe the Lower Mississippi River can be managed for flood risk management and navigation, in addition to ecosystem restoration and recreation. Please give this proposal your full consideration.

Sincerely,

Jonathan McFarland, P.E.
Administrator
Water Planning and Assessment

Additional Proposal Information

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LockLevenlandownerLTRofSup.pdf

August 1, 2017

Ms. Lisa Kiefel
Planning and Policy Division
USACE – Headquarters
441 G St. N.W.
Washington, D.C. 20314

Dear Ms. Kiefel:

My family owns a property called Loch Leven near Lake Mary in Wilkinson County, Mississippi. The property consists of approximately 6,000 acres of cropland, timberland and aquaculture in the Mississippi batture, and has frontage on the Mississippi River. We are interested in creating a sustainable and productive landscape for wildlife in harmony with the Mississippi River. We are frequently impacted by high water resulting in lost crops, destroyed levees and impacted infrastructure. We are striving to achieve a better solution whereby our lands are more resilient over time and more ecologically productive. That is why we support the Feasibility Study being proposed by The Nature Conservancy that will hopefully launch work on key recommendations from the Lower Mississippi River Resource Assessment (LMRRA). This proposal would help to: 1) establish a water quality monitoring program in the lower Mississippi River and 2) Conduct eight conservation reach habitat restoration and recreation enhancement studies on the Lower Mississippi River. This reasonable step will assure the Lower Mississippi River continues to provide for people and the natural inhabitants of the river system.

The Lower Mississippi River is a great river that receives flow from Upper Mississippi, Ohio, Missouri, Arkansas/Red Rivers and guides that flow to the Gulf of Mexico. This river has experienced numerous great floods while also carrying $50,000,000,000 worth of agricultural products to export markets each year. The river is the economic and cultural driver for the people who are live along the banks. As mentioned, my family has endured these floods that have become more frequent and more intense over the past 10 years.

For almost two centuries people have modified the river dynamics to cope with floods and keep navigation traffic moving along the most extensive inland waterway system in the world. These changes to the river valley were necessary but over time they degraded the natural forests, wetlands, channels, oxbows and bayous vital for plants, animals, fish that historically thrived within the river. Today, we better understand the interactions between what people need to live with the river and how to balance those uses with the needs of a natural river system. My family is presently working with The Nature Conservancy to find such a balance.

There is an opportunity to move toward an improved Lower Mississippi River that serves our needs and provides essential river health for the diverse species that reside or migrate through the Lower Mississippi River. Building from past planning activities included in Restoring America's Greatest River plan and the Lower Mississippi River Resource Assessment, partners will prepare a Feasibility Study designed to implement priority restoration projects and establish sequencing for the projects that should follow. At the same time, the fundamentals of

establishing a Water Quality Monitoring program will be addressed with an end-product that is ready for implementation. Water quality information is vital for managing the ecological health of the river but also provides valuable information for flood risk management and navigation.

I want to add our voice to the many partners that believe the Lower Mississippi River can be managed for flood risk management, navigation plus ecosystem restoration and recreation. Please give this proposal your full consideration.

Sincerely,

Erik Piazza
Loch Leven Plantation