DRAFT ENVIRONMENTAL ASSESSMENT

WITH

UNSIGNED FINDING OF NO SIGNIFICANT IMPACT

REGULATING WORKS PROJECT
DOGTOOTH BEND PHASE 5
MIDDLE MISSISSIPPI RIVER MILES 40.0-20.0
ALEXANDER COUNTY, IL
MISSISSIPPI AND SCOTT COUNTIES, MO

DECEMBER 2013

US Army Corps
of Engineers
St. Louis District

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1. Purpose of and Need for Action

The U.S. Army Corps of Engineers St. Louis District (District) is responsible for providing a safe and dependable navigation channel, 9 feet deep and not less than 300 feet wide, with additional width in the bends as required, on the Middle Mississippi River (MMR). The MMR is defined as that portion of the Mississippi River that lies between the confluences of the Ohio and Missouri rivers (Figure 1). This is achieved through the authorized Regulating Works Project. The Regulating Works Project consists of bank stabilization and sediment management to ensure adequate navigation depth and width. Project improvements are achieved through the construction of river training structures, revetment, rock removal, and construction dredging. The Regulating Works Project is maintained through dredging and any needed maintenance to already constructed features. The long-term goal of the Regulating Works Project, as authorized by Congress, is to alleviate or eliminate the amount of annual maintenance dredging and the occurrence of vessel accidents through the construction of river training structures to provide a sustainable navigation channel and reduce federal expenditures. Since the 1970s various environmental laws, regulations, and policies have resulted in considering the environment in the design and construction of the Regulating Works Project.

The Regulating Works, Dogtooth Bend Phase 5 Construction Project (Dogtooth Bend Phase 5 Project) is needed to address repetitive channel maintenance dredging issues in the project area. Frequent dredging has been required in the area in order to address channel depth, width, and alignment issues. Construction of river training structures would provide a sustainable alternative to repetitive maintenance dredging. Construction of the Dogtooth Bend Phase 5 Project is proposed to begin in 2014.

The planning of specific construction projects for the Regulating Works Project, including the Dogtooth Bend Phase 5 Project, requires extensive coordination with resource agency partners and the navigation industry. The U.S. Fish and Wildlife Service (USFWS), Missouri Department of Conservation (MDC), Illinois Department of Natural Resources (IDNR), and multiple navigation industry groups were involved in the planning of the Dogtooth Bend Phase 5 Project.

Prior Reports

This site-specific Environmental Assessment (EA) is tiered off of the 1976 Environmental Impact Statement (1976 EIS) covering the District's Regulating Works Project – *Mississippi River between the Ohio and Missouri Rivers (Regulating Works)*, (USACE 1976). The 1976 EIS was recently reviewed by the District to determine whether or not the document should be supplemented. The District has concluded that the Regulating Works Project has not substantially changed since 1976 but that there are significant new circumstances and information on the potential impacts of the Regulating Works Project on the human environment to warrant the preparation of a Supplemental EIS (SEIS). The Dogtooth Bend Phase 5 Project EA will incorporate any new information and circumstances relevant to the impacts of the action on the human environment to the greatest extent possible. Should the analyses undertaken as part of the SEIS process reveal any new impacts on the human environment not accounted for in this EA, measures will be taken within our authority to avoid, minimize, and/or compensate for the impacts during that process as appropriate. Information on the SEIS can be found in the

Notice of Intent that was published in the Federal Register on December 20, 2013. The Notice of Intent can be found at the following link:

https://www.federalregister.gov/articles/2013/12/20/2013-30347/intent-to-prepare-a-draft-supplemental-environmental-impact-statement-for-the-middle-mississippi

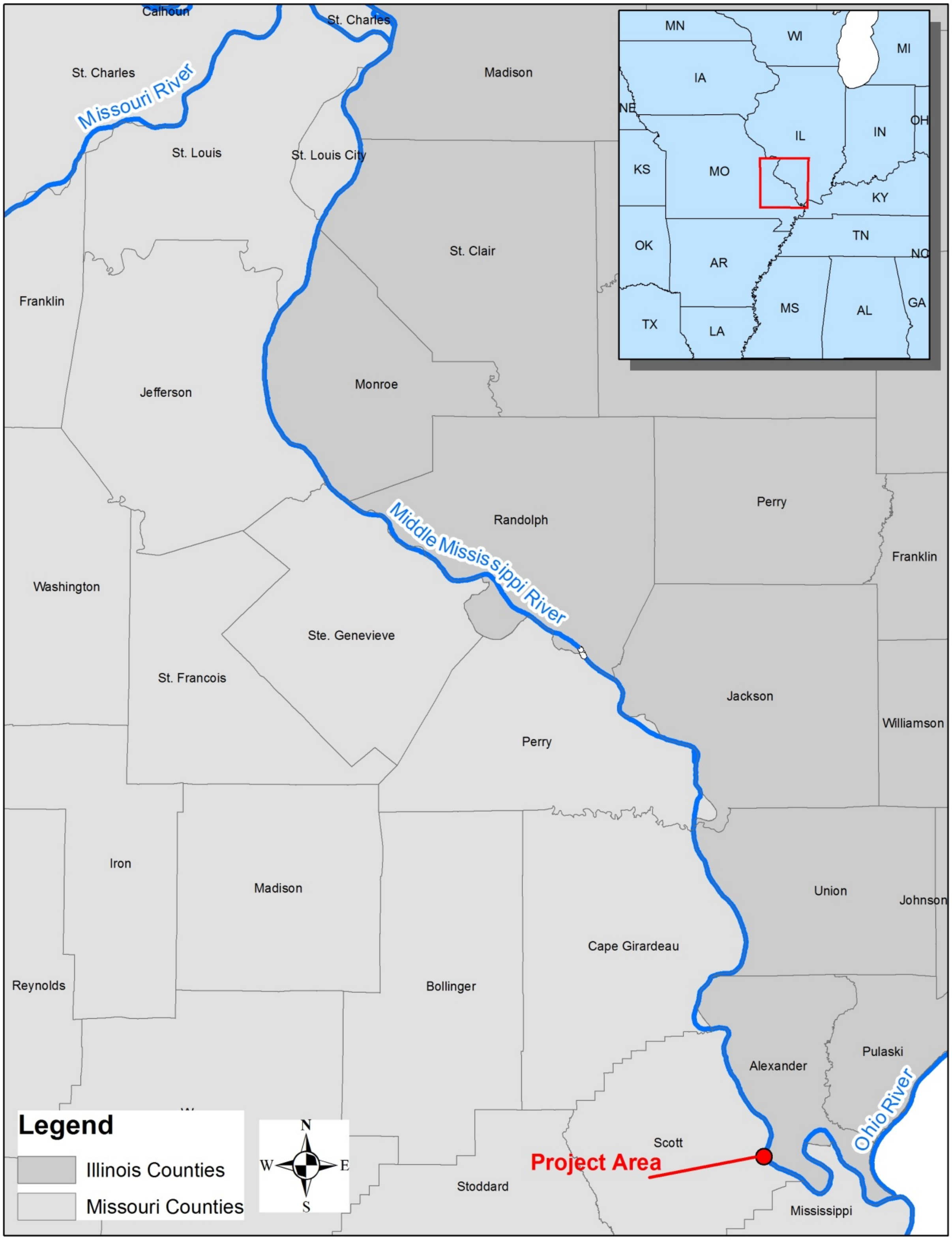

Figure 1. Project location within the MMR

2. Alternatives Including the Proposed Action

This section describes the alternatives or potential actions that were considered as ways to address the issues with maintaining the depth, width, and alignment of the navigation channel at the Dogtooth Bend Phase 5 Project site. The primary biological goal of the project is to minimize negative impacts to the environmental features within the reach and specifically to maintain existing physical conditions in the side channel. Alternatives will be described and their environmental impacts and usefulness in achieving the project objectives will be compared.

Alternative 1: No Action Alternative. The No Action Alternative consists of not constructing any new river training structures in the project area but continuing to maintain the existing river training structures. Dredging would continue as needed to address the shoaling issue in the project area to fulfill the project's navigation purpose.

Alternative 2: Proposed Action. The Proposed Action consists of construction of two bendway weirs near river mile (RM) 34.0, four bendway weirs near RM 32.0, a dike at RM 31.6 and two bendway weirs near RM 31.0 (Table 1, Figure 2).

Table 1. Features associated with the Proposed Action.

Location by river mile	Work to be completed	Potential Physical Results (from Hydraulic Sediment Response Model)
34.2 (L)	Construct bendway weir 600 feet long -Top elevation of the Weir will be 277.5 (-20 feet Low Water Reference Plane).	The proposed bendway weirs at RM 34.2, 34.1, 32.5, and 32.2 (L) improved the width of the channel at RM 34.00, and reduced the sedimentation in the channel between RM 31.9-31.6. Dike 31.6 (R) provided more constriction to the channel, thus, contributing to the sediment reduction. Weirs 30.8 & 30.7(R) helped the flow transition from the crossing into the bend at RM 31.00. The design alternative also showed great improvement in the channel depth between RM 29.00 - 27.20 although there was some slight sedimentation. The channel was also wider along the bendway weir field between RM 30.6 - 29.15 without affecting Bumgard Island or its side channel.
34.1 (L)	Construct bendway weir 600 feet long -Top elevation of the weir will be 277.25	
32.5 (L)	Construct bendway weir 400 feet long -Top elevation of the weir will be 281.1 (-15 feet Low Water Reference Plane).	
32.4 (L)	Construct bendway weir 500 feet long -Top elevation of the weir will be 281.0	
32.3 (L)	Construct bendway weir 650 feet long -Top elevation of the weir will be 280.9	
32.2 (L)	Construct bendway weir 500 feet long -Top elevation of the weir will be 280.8	
31.6 (R)	Construct Dike 300 ft long -Top elevation of the dike will be 310.4 (+15 feet Low Water Reference Plane).	
30.8 (R)	Construct bendway weir 160 ft long -Top elevation of the weir will be 274.75 (-20 feet Low Water Reference Plane).	
30.7(R)	Construct bendway weir 162 ft long -Top elevation of the weir will be 274.65	

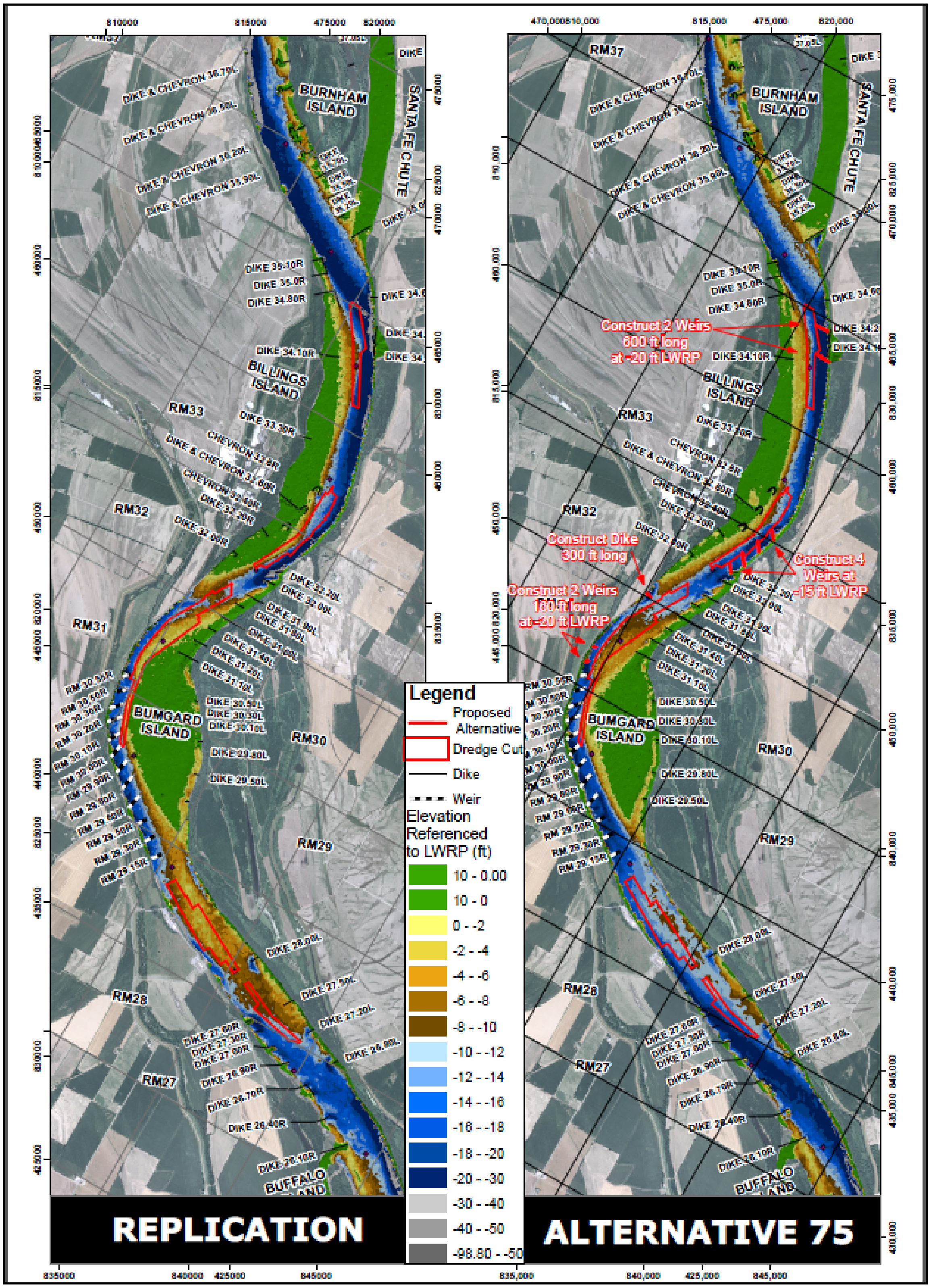

Figure 2. Features associated with the Proposed Action.

Development of Alternatives. In order to develop potential alternatives to address the navigation channel problems in the Dogtooth Bend Phase 5 Project area, the District utilized a Hydraulic Sediment Response model (HSR model). An HSR model is a small-scale physical sediment transport model used by the District to replicate the mechanics of river sediment transport. To date, HSR models have been used in over 50 river engineering studies to solve complex sediment transport problems. Monitoring of the approximately 20 constructed projects, including detailed bathymetric analysis, has demonstrated the predictive capability of HSR models. HSR models allow the District to develop multiple configurations of river training structures for addressing the specific objectives of the project in question in a cost-effective and efficient manner. The process of alternatives development using an HSR model starts with the District calibrating the model to replicate project site conditions.

Various configurations of river training structures are then applied to the model to determine their effectiveness in addressing the needs of the project. For the Dogtooth Bend Phase 5 Project, the District utilized the Bumgard Island HSR model study. The Bumgard Island HSR model study analyzed 85 different configurations of bendway weirs, dikes, chevrons and W-dikes to determine the best combinations to reduce the need for dredging, improve navigation channel alignment, and minimize environmental impacts. Several alternatives showed a reduction in deposition that occurs at the dredging locations between RM 34.50 - 27.00 but did not completely eliminate the problem. Other alternatives showed that dredging was completely eliminated but raised concerns regarding environmental features in the reach, particularly impacts to the downstream island and side channel.

In a meeting with the MDC, IDNR, the USFWS (Fisheries and Ecological Services), and industry groups on 19 September, 2013, and after many prior group discussions with resource agencies and industry, it was agreed upon that “Alternative 75” achieved the best balance of the study’s goals and was the recommended alternative. Resource agency concerns about potential impacts to the Bumgard Island “complex” (e.g., pallid sturgeon and least tern habitat) also guided the alternative analysis. Concerns included, (1) potential impacts to flows in the existing side channel which could affect pallid sturgeon habitat, (2) potential impacts to the large gravel bar on the upper half of the island and the lower half of the island that provides a diversity of gradual sloping banks and shallow water habitat (limiting habitat in the Mississippi), which has been documented as being used by young of year pallid sturgeon, and (3) an overall reduction in the size of the island. Alternative 75 showed reduction in sedimentation between RM 34.50 - 27.00 while appearing to avoid impacts to Bumgard Island and its side channel. Note that while there was a reduction in sedimentation, the bendway weirs will not completely eliminate the need to dredge at RM 33.00 or RM 28.00.

Detailed information on the Alternatives development process, partner agency coordination, and alternatives eliminated from further consideration can be found in the on-line HSR model study report, see Bumgard Island at:

http://mvs-wc.mvs.usace.army.mil/arec/Reports_HSR_Model.html

Summary of Environmental Consequences
The impacts of each Alternative on the human environment are covered in detail in Chapter 4, Environmental Consequences. Table 2 below provides a summary of the impacts of each Alternative by resource category.

Table 2. Summary of impacts of the No Action and the Proposed Action.

	No Action Alternative	**Proposed Action**
Achievement of project objectives	Does not reduce the need for repetitive maintenance dredging in the project area, and, therefore, does not meet the project objectives.	Is expected to reduce the amount of repetitive maintenance dredging in the project area, thereby reducing federal expenditures and meeting project objectives.
Impacts on Stages	No impacts anticipated.	No impacts anticipated at average and high flows. At low flows, current trend of decreasing stages expected to continue.
Impacts on Water Quality	Localized, temporary increase in suspended sediment concentrations at discharge sites.	Localized, temporary increase in suspended sediment concentrations during construction activities.
Impacts on Air Quality	Minor, local, ongoing impacts due to use of dredging equipment.	Temporary, minor, local impacts due to one-time use of construction equipment.
Impacts on Fish and Wildlife	Entrainment of fish and macroinvertebrates at dredge locations. Avoidance of dredge and disposal areas by mobile organisms. Loss of fish and macroinvertebrates at disposal sites.	Avoidance of sites during construction. No conversion of aquatic habitat to terrestrial. Increased fish and macroinvertebrate use of structure locations due to increased bathymetric, flow, and substrate diversity. Uncertain impacts on fish and macroinvertebrates at inside bend opposite of proposed bendway weir locations.
Impacts on Threatened and Endangered Species	Impacts are consistent with those addressed in the USFWS 2000 Programmatic Biological Opinion.	Impacts are consistent with those addressed in the USFWS 2000 Programmatic Biological Opinion.
Impacts on Navigation	Continued requirement for periodic maintenance dredging at rates similar to recent history.	Reduction in the amount and frequency of periodic maintenance dredging in the project area.
Impacts on Historic and Cultural Resources	Impacts to historic and cultural resources unlikely.	Impacts to historic and cultural resources unlikely.

3. Affected Environment

This section presents details on the historic and existing conditions of resources within the project area that would potentially be affected by project-related activities. The section is broken into four resource categories: physical resources, biological resources, socioeconomic resources, and historic and cultural resources. This section does not address impacts of the Alternatives, but provides a background against which Alternatives can be compared in Section 4, Environmental Consequences.

Physical Resources

Stages - Rated gages, locations where both discharge and stage is collected and combined to create a rating curve, are good sources of long term stage and discharge data. Only three rated gages exist on the MMR: St. Louis, Chester and Thebes. Due to backwater effects from the Ohio River the gage at Thebes is not a good indicator of changes in stage over time. Throughout the period of record the two agencies that have been responsible for the collection of gage data on the MMR are the Corps of Engineers and U.S. Geological Survey (USGS). The USGS has been the primary agency responsible for stream gaging since 1933. Due to discrepancies in methodology and instrumentation used by the Corps and USGS it is impossible to analyze the entire period of record with confidence; therefore only data collected by the USGS will be used here to describe the changes in stage for fixed discharges over time (Watson et al. 2013a; Watson et al. 2013b; Huizinga 2009; Munger et al. 1976).

Stages have been decreasing over time for flows below 200,000 cfs at the St. Louis gage (Figure 3). For other in-bank flows between 200,000 cfs and 500,000 cfs there has been no change over time. There is a slight upward but statistically insignificant trend for stages at the overbank flow of 700,000 cfs. Stages at Chester for lower in-bank flows up to 200,000 cfs have decreased with time. There was no change in stages at flows of 200,000 cfs and 400,000 cfs. There was a slightly increasing trend at 300,000 cfs. For overbank flows of 500,000 cfs and 700,000 cfs, there were slight increasing trends observed at the Chester gage.

In general, at both the St. Louis and Chester gages there has been a decrease in stage over time for lower flows, no change in stages over time for flows between midbank and bankfull, and a slight increase in stages for high overbank flows (Huizinga 2009). Huizinga (2009) and Watson et al. (2013a) attributed the slight increase in out of bank flows to the construction of levees and the disconnection of the river from the floodplains. Both Watson et al. (2013a) and Huizinga (2009) observed a shift occurring in the out of bank flows in the mid-1960s and attributed it to the completion of the Alton to Gale levee system which paralleled the entire MMR. At these high flows navigation structures are submerged by 7 to 10 feet.

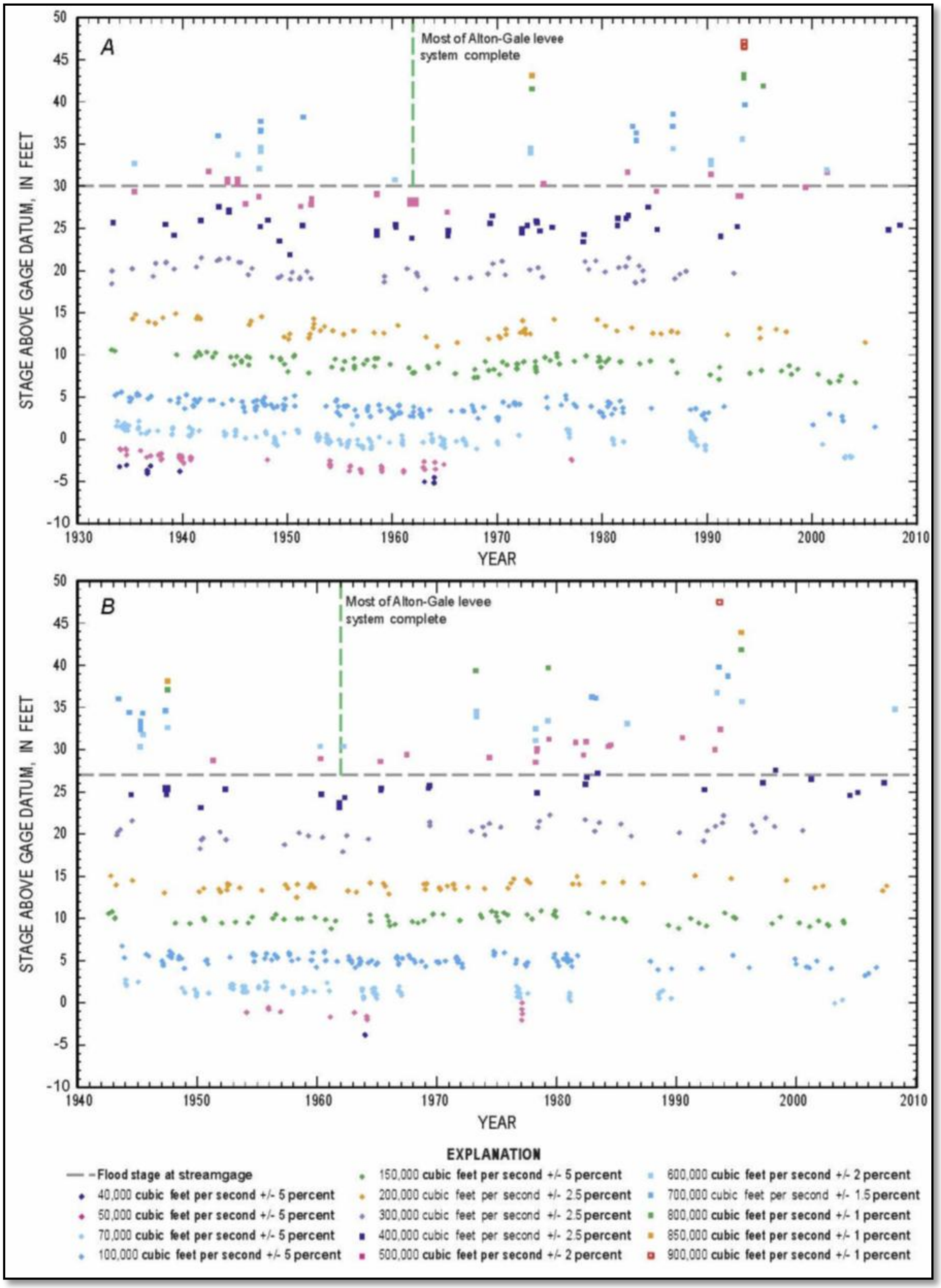

Figure 3. Stage for a given discharge range with time from measurements made at the streamgages at (A) St. Louis, Missouri, and (B) Chester, Illinois, on the MMR (from Huizinga 2009).

Water Quality – Consideration of water quality encompasses a wide range of physical, hydrologic, and biological parameters. Watershed influences, including tributary streams, point and non-point pollution sources, flow alteration due to navigation structures, and drought and flood events all influence water quality. Variations in land use practices, cover types, and watershed area will determine the level and type of sediment, nutrient, and contaminant inputs into the Mississippi River and its tributaries. The Mississippi River has a long history of water quality impairment due to contamination from industrial, residential, municipal, and agricultural sources. Recent changes in wastewater treatment laws and technologies, regulation of point source discharges, and changes in public awareness have contributed to overall improvements in water quality.

Section 303(d) of the Clean Water Act requires states to generate lists of impaired water bodies every two years. Impaired water bodies are those that do not meet state water quality standards for the water bodies' designated uses. On the 2012 303(d) list for Illinois, the Mississippi River in the vicinity of the project area was listed as impaired for fish consumption due to mercury and polychlorinated biphenyls (PCB) contamination, impaired for public and food processing water supplies due to manganese concentration, and impaired for primary contact recreation due to fecal coliform bacteria contamination. The Mississippi River is not on the 2012 303(d) list for Missouri.

Illinois has fish consumption advisories for the Mississippi River for channel catfish (one meal per week), common carp (one meal per week), and sturgeon (one meal per month) due to PCB contamination. Missouri has fish consumption advisories for the Mississippi River for shovelnose sturgeon (1 per month) due to PCB and chlordane contamination, and for flathead catfish, blue catfish, channel catfish, and common carp (1 per week) due to PCB, chlordane, and mercury contamination.

Air Quality – The Clean Air Act requires the Environmental Protection Agency (EPA) to set National Ambient Air Quality Standards for six criteria air pollutants: ozone, particulate matter, carbon monoxide, nitrogen oxides, sulfur dioxide, and lead. EPA regulates these pollutants by developing human health-based or environmentally-based permissible pollutant concentrations. EPA then publishes the results of air quality monitoring, designating areas as meeting (attainment) or not meeting (nonattainment) the standards. Scott and Mississippi Counties, Missouri and Alexander County, Illinois are designated as attainment areas for all six criteria air pollutants (USEPA 2013).

Biological Resources

Fish and Wildlife – The changes in fish and wildlife habitat in the Mississippi River Basin that have occurred over the past 200 years are well documented. Many studies have analyzed the historic changes in habitat in the Mississippi River Basin from pre-colonization times to present day (Simons et al. 1974; UMRBC 1982; Theiling et al. 2000; WEST 2000; and Heitmeyer 2008). A variety of actions have impacted the makeup of the Mississippi River basin since colonization including urbanization, agriculture, levee construction, dam construction, and river training structure placement. Many of the changes in the MMR planform are attributable to improvements made for navigation including river training structure placement and associated sedimentation patterns.

An analysis of changes in river planform in the MMR was recently conducted by the District (Brauer et al. 2005; Brauer et al. 2013). The analysis utilized historic and modern maps, surveys, and aerial photography to calculate changes through time in planform width, channel width, channel surface area, side channel width, etc. The analysis demonstrates that the MMR went through a period of planform widening in the mid-nineteenth century followed by a period of planform narrowing from the end of the nineteenth century through the mid-twentieth century. The period of narrowing corresponded to the widespread use of river training structures and bank protection for navigation improvements. The first training structures were mainly permeable wooden structures which focused the river's energy into the main channel by reducing the velocities between the structures, causing sediment to deposit in channel border areas. This sediment deposition caused a significant narrowing effect on the channel. Since 1968, however, the channel width appears to have reached dynamic equilibrium with very little change (see Figure 4 below). In the 1960s, the Corps began constructing impermeable dikes primarily out of stone. The use of impermeable dikes reduced the rate of deposition between the structures when compared to the previously used permeable structures. Another change was the reduction of the design elevation of dike fields. Unlike in the past, the area between the structures did not fill with sediment, grow vegetation and become part of the floodplain. In the 43 years between 1968 and 2011 the average planform width remained relatively steady with a net reduction in average planform width of 167 feet. This was the result of the changes in structure material and elevation.

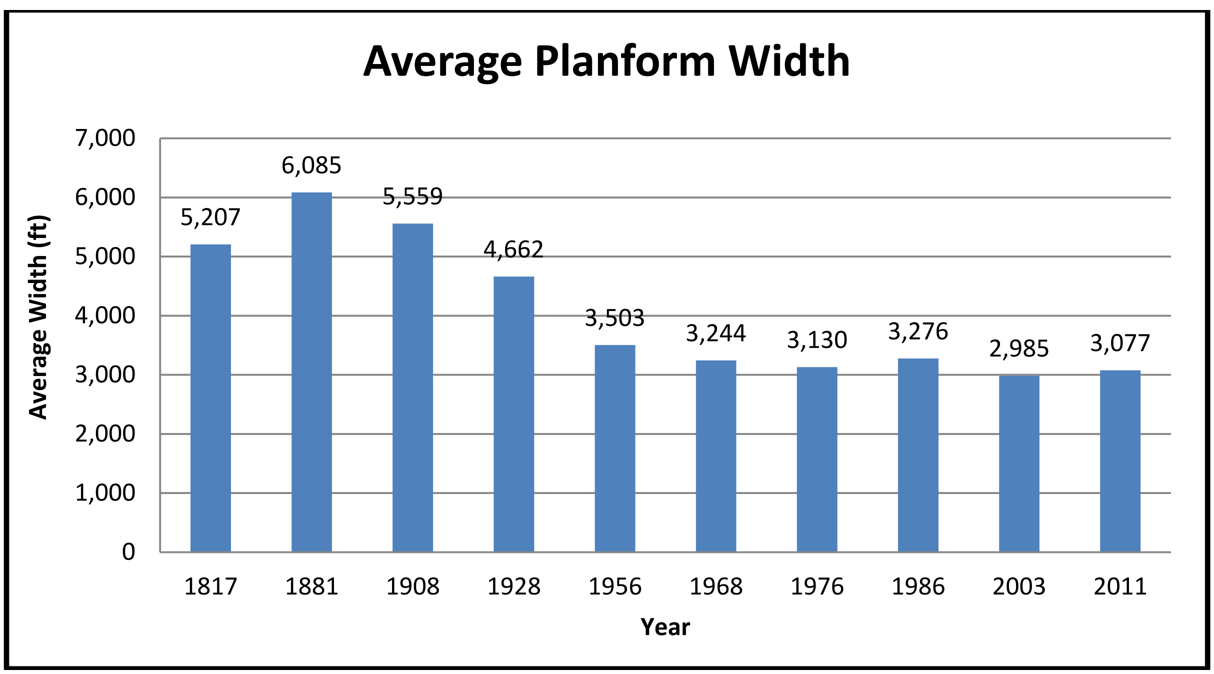

Figure 4. Average planform width of the MMR from 1817 to 2011.

In response to natural resource agency partner concerns about the potential impacts of traditional dikes on fish and wildlife habitat, the St. Louis District began to experiment with innovative dike configurations that attempt to achieve the navigational objectives of a safe and dependable navigation channel in an environmentally sensitive manner. The District has designed and implemented many different dike configurations including notched dikes, rootless dikes, L-dikes, W-dikes, chevron dikes, multiple roundpoint structures, etc. The intent of the innovative dike designs is to provide bathymetric and flow diversity compared with the traditional structures constructed since the 1960s while maintaining the function of deepening the navigation channel. The District currently builds very few traditional wing dike structures in the MMR.

The fish community in the project area is expected to be typical of the MMR fish community in general. Fish community monitoring (Upper Mississippi River Restoration - Environmental Management Program Long Term Resource Monitoring Program) conducted in the vicinity (MMR miles 80 to 29) of the Dogtooth Bend Phase 5 Project in main channel border areas from 2000 to 2012 collected 89 species of fish. The most commonly encountered native species included gizzard shad (*Dorosoma cepedianum*), channel catfish (*Ictalurus punctatus*), freshwater drum (*Aplodinotus grunniens*), emerald shiner (*Notropis atherinoides*), smallmouth buffalo (*Ictiobus bubalus*), channel shiner (*N. wickliffi*), white bass (*Morone chrysops*), shortnose gar (*Lepisosteus platostomus*), blue catfish (*I. furcatus*), and river carpsucker (*Carpiodes carpio*). These species accounted for approximately 70% of the fish captured, by number. Also included in the collection were 4 species of non-native fish including common carp (*Cyprinus carpio*), silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*), and bighead carp (*Hypophthalmichthys nobilis*). These species accounted for approximately 11% of the fish captured, by number, with the vast majority being common carp. Silver carp were likely under-represented in the collection due to the sampling methodologies employed. The area sees some commercial and recreational fishing pressure. Commercial fishermen typically target common carp, bigmouth and smallmouth buffalo, catfish, freshwater drum, and recently silver carp. Recreational fishermen typically target catfish.

Macroinvertebrates are an important part of the river ecosystem as they serve as a food source for a variety of fish and wildlife species. Common macroinvertebrate fauna encountered in the MMR consist of a variety of oligochaete worms, flies, mayflies, caddisflies, and stoneflies. Sampling by Battle et al. (2007) near Cape Girardeau, Missouri showed densities of macroinvertebrates in fine substrates downstream from wing dikes ranging from approximately 3,700 to 11,700 individuals per square meter. Sixty-eight taxa were collected from fine sediments with the dominant groups being oligochaete worms, midges, and mayflies. Densities on rocks on the upstream side of wing dikes ranged from 57,800 to 163,000 individuals per square meter. Fifty taxa were collected from rock substrate with the dominant group being caddisflies.

Macroinvertebrates were also collected from rock surfaces in bendway weir fields in the MMR at river mile 164 near Oakville, Missouri (Ecological Specialists 1997a) and at river mile 30 near Commerce, Missouri (Ecological Specialists 1997b). Twenty-nine taxa were collected at river mile 164 with caddisflies being the overwhelmingly dominant group; midges were also abundant. Density averaged 14,662 individuals per square meter. Thirty-four taxa were collected at river mile 30 with caddisflies again the overwhelmingly dominant group; midges were present but not as abundant as at river mile 164. Density averaged 16,240 individuals per square meter. Sampling conducted in sand substrate at a nearby bendway without bendway weirs (river mile 20) yielded 7 taxa and 965 individuals per square meter with oligochaete worms being the overwhelmingly dominant group.

Threatened and Endangered Species - According to U.S. Fish and Wildlife Service database queries, nine federally threatened or endangered species could potentially be found in the project area (Mississippi and Scott Counties, Missouri, and Alexander County, Illinois). The nine species, federal protection status, and habitat can be found in Table 3. No critical habitat is located in the project area.

Table 3. Federally listed threatened and endangered species potentially occurring in the project area.

Species	**Fed Status**	**Habitat**
Indiana bat (*Myotis sodalis*)	Endangered	Hibernacula in caves and mines; Maternity and foraging habitat - small stream corridors with well developed riparian woods; upland and bottomland forests
Gray bat (*Myotis grisescens*)	Endangered	Caves and mines; forages over rivers and reservoirs adjacent to forests
Northern long-eared bat (*Myotis septentrionalis*)	Candidate	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
Least tern (interior population) (*Sternula antillarum*)	Endangered	Large rivers - nest on bare alluvial and dredge spoil islands
Pallid sturgeon (*Scaphirhynchus albus*)	Endangered	Mississippi and Missouri Rivers
Fat pocketbook pearly mussel (*Potamilus capax*)	Endangered	Large Rivers in slow-flowing water in mud and sand.
Sheepnose *(Plethobasus cyphyus)*	Endangered	Shallow areas in larger rivers and streams
Rabbitsfoot (*Quadrula cylindrical cylindrical*)	Threatened	Small to large rivers in sand and gravel
Decurrent false aster (*Boltonia decurrens*)	Threatened	Recently disturbed areas within wet prairies, shallow marshes, and shores of open rivers, creeks and lakes

Socioeconomic Resources

Navigation

The MMR is a critically important navigation corridor that provides for movement of a wide variety of commodities of local, national, and international importance. Approximately 106 million tons of cargo passed through the MMR in 2011, the most recent year with data available (USACE 2013). Food and farm products (37 million tons), coal (26 million tons), crude materials (14 million tons), fertilizers (12 million tons), and petroleum products (10 million tons) accounted for the majority (93%) of shipments in 2011.

Dredging in the Mississippi River is commonly used to provide required navigation dimensions of depth, width, alignment, or a combination thereof. In this project area repetitive channel maintenance dredging was required in four different areas along the reach (Figure 5). The sandbar located along the Right Descending Bank (RDB) near RM 35.00 to 31.80 has grown in size between RM 34.50 to 33.80 and RM 32.90 to 31.50. Bumgard Island, located along the Left Descending Bank (LDB) between RM 31.00 to 29.00, has also grown causing shoaling between RM 31.40 to 30.60. Downstream of Bumgard Island on the LDB, shoaling has occurred between RM 28.90 to 27.20. On average, dredging in this reach has been required nearly every year from 2001 to 2012. During this twelve year period, the following total estimates of dredge material quantities in cubic yards (cy) and costs were calculated:

- RM 34.50 to 33.80: 315,516 cy at a cost of $408,414
- RM 32.90 to 31.50: 946,670 cy at a cost of $2,328,255
- RM 31.40 to 30.60: 639,035 cy at a cost of $973,146
- RM 28.90 to 27.20: 1,201,738 cy at a cost of $1,930,945.

Historic and Cultural Resources

The bankline of the Bumgard Reach has significantly changed in the past century and a half. The locations of seven of the in-water features were on land as late as 1908. Conversely, due to the Mississippi's migration most of the other feature locations were closer to the middle of the channel than they are now. It was not until the first quarter of the twentieth century that the shoreline stabilized near its current position. The construction of revetments and river regulating structures, including those used to close the western branch of the river (i.e., the Doolan Slough), were responsible for the stabilization. Any cultural resources located on land eroded prior to that stabilization would have been destroyed by the bankline recession and any shipwreck located there would post date it.

During the summer of 1988 when the Mississippi River was at its lowest level on record, the St. Louis District Corps of Engineers conducted an aerial survey of exposed wrecks between Saverton, Missouri, and the mouth of the Ohio River. The nearest observed wreck to the project features was located approximately at river mile 33.5R within the reach. The wreck, however, was sighted on the opposite bank and downstream from the nearest feature (Weir 32.2L), while the nearest feature on the same bank is approximately two miles downstream.

The Bumgard Reach has been regularly dredged over the years, and it is likely that any unrecorded wreckage located in the path of those dredge events was destroyed and removed during the process. Most of the proposed structures are next to dredged channels, which probably resulted in channel slump and sediment reworking in these locations.

The river bed in the project area is surveyed every two to three years, with the latest survey having been completed on July 20, 2011, or June 21, 2012 (depending upon the river section). The single-beam survey was conducted with range lines spacing of 250 feet. No topographic anomalies suggesting wrecks are visible on the resulting bathymetric map. Where higher resolution multi-beam surveys were available, they were also examined, and no anomalies were visible.

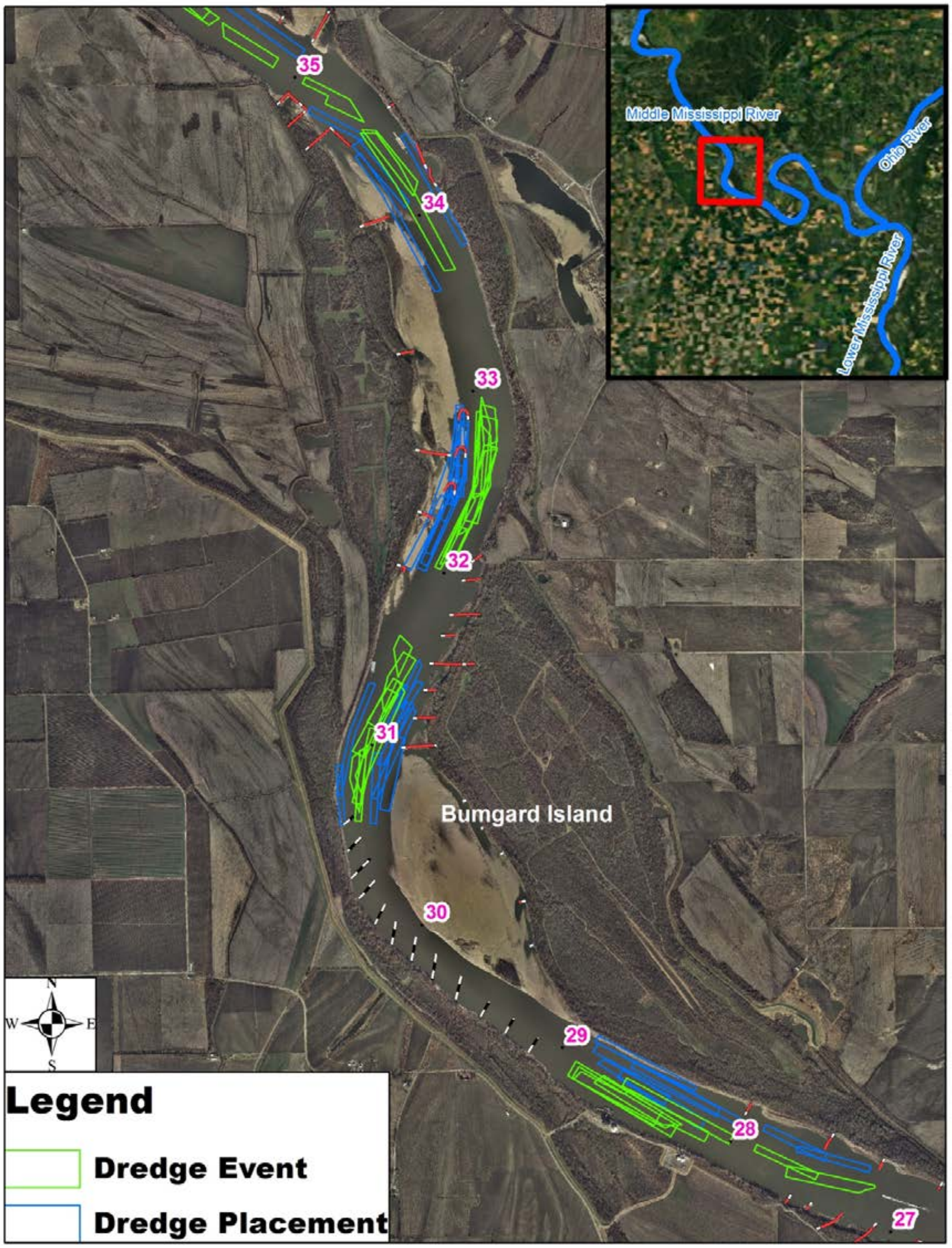

Figure 5. Repetitive dredging areas in the vicinity of the project since 2000.

4. Environmental Consequences

The Environmental Consequences Section of this report details the impacts of the Alternatives on the human environment. The section is organized by resource, in the same order in which they were covered in Section 3, Affected Environment. Within each resource category, impacts will be broken out by Alternative. The No Action Alternative consists of not constructing any new river training structures in the project area but continuing to maintain the existing river training structures. Dredging would continue at levels similar to recent history as needed to address the shoaling issue in the project area. The Proposed Action consists of construction of two bendway weirs near RM 34.00, four bendway weirs near RM 32.00, a dike at RM 31.60 and two bendway weirs near RM 31.00.

Physical Resources

Stages

Impacts of the No Action Alternative on Stages – Stages in the vicinity of the project area and the MMR would be expected to be similar to current conditions under the No Action Alternative.

Impacts of the Proposed Action on Stages – With implementation of the Proposed Action, stages at average and high flows both in the vicinity of the project area and on the MMR are expected to be similar to current conditions. An abundance of research has been conducted analyzing the impacts of river training structures on water surfaces dating to the 1940s. This research has analyzed historic gage data, velocity data, and cross sectional data. Physical and numerical models have also been used to determine the effects of dikes on water surfaces. It should be noted that some published research supports the contention that river training structures raise flood heights. A summary of research on the effects of river training structures on flood heights can be found in Appendix A. Based on an analysis of this research by the Corps and other external reviewers, the District has concluded that river training structures do not affect water surface elevations at higher flows.

With respect to water surface elevations at low flows, analysis of the data shows a trend of decreasing stages over time. This decrease could be a result of river training structure placement and/or a decrease in the sediment load in the river due to construction of reservoirs on Mississippi River tributaries (Huizinga 2009). The same conclusion regarding decreasing stages at low flows was reached in the 1976 Regulating Works EIS (USACE 1976). The 1976 EIS concluded that, as a result of stage decreases, many of the remaining side channels in the MMR might be lost at some point in the future due to sedimentation. While much research has been performed on the impacts of river training structures at high flows, similar research has not been performed on the impacts at low flows. However, since the 1976 EIS, there has been an increasing recognition of the importance of side channel habitat on the MMR and increased emphasis on side channel restoration. Through the District's Biological Opinion Program, (http://mvs-wc.mvs.usace.army.mil/arec/Bio_Op.html, Avoid and Minimize Program (http://mvs-wc.mvs.usace.army.mil/arec/AM.html), innovative river training structure design, and other restoration initiatives, side channel restoration and preservation on the MMR has occurred and will continue to occur for the foreseeable future, resulting in a substantial preservation of the side channels that existed in 1976. While the Proposed Action may have some effect on water surface elevations at lower flows resulting in some impact to side channels, these impacts are being minimized through other USACE programs, which have currently seen success in restoring and preserving side channels affected by river training structures.

Water Quality

Impacts of the No Action Alternative on Water Quality – Periodic dredging activities would continue to cause re-suspension of river sediments at the point of discharge, causing turbidity, increased suspended sediment concentration, and decreased light penetration. The impact would be localized and would dissipate quickly. Dredged sediments in the area are typically sand with little associated fines and would, therefore, not be expected to release contaminants into the water column at concentrations that alone or in combination with other contaminants would cause toxic effects to aquatic organisms.

Impacts of the Proposed Action on Water Quality – Construction activities would cause temporary increases in turbidity and suspended sediment concentrations in the immediate vicinity of the structure locations. The impact would be localized and would dissipate quickly. Sediments in the area are typically sand with little associated fines and would, therefore, not be expected to release contaminants into the water column at concentrations that alone or in combination with other contaminants would cause toxic effects to aquatic organisms.

The proposed structures are designed to change the sedimentation patterns in the project area and would, therefore, cause some minor temporary changes in the suspended sediment concentration in the area. Limestone material used for construction could potentially affect local water chemistry (e.g., alkalinity, hardness, and pH). However, given the prevalence of limestone in the watershed geology and the quick dissipation of any associated fine materials in the water column, the impact is likely to be negligible.

The District is currently in the process of obtaining authorization for the project under sections 404 and 401 of the Clean Water Act. All permits necessary for completion of the project will be obtained prior to project implementation (Appendix D).

Air Quality

Impacts of the No Action Alternative on Air Quality – Air quality in the vicinity of the project area would be expected to be similar to current conditions. Equipment used for repetitive dredging activities would generate emissions on an occasional, ongoing basis from the use of petroleum products. Impacts would be minor and local in nature.

Impacts of the Proposed Action on Air Quality – Air quality in the vicinity of the project area would be expected to be similar to current conditions. Equipment used for construction activities would generate emissions from the use of petroleum products but impacts would be temporary, minor, and local in nature.

Biological Resources

Fish and Wildlife

Impacts of the No Action Alternative on Fish and Wildlife – Periodic maintenance dredging and dredged material disposal operations would have the potential to affect fish and wildlife resources through direct removal of individual organisms (entrainment) at the dredging site. The degree to which fish and wildlife resources are impacted is largely a factor of the density of the organisms in the area of the dredge cut at the time of dredging operations. Macroinvertebrate densities tend to increase with greater sediment stability, lower water velocities, and higher silt and organic matter concentrations (Galat et al. 2005). Given the shifting nature of the sediments, high water velocities, and low silt concentrations in the main channel of the MMR, the area is not ideal habitat for colonization by bottom-dwelling macroinvertebrates (Koel and Stevenson 2002; Sauer 2004), but likely provides habitat for low densities to exist. Various fish species likely utilize the habitat as well and could be impacted at dredge sites. The Corps' Engineer Research and Development Center published a Technical Note in 1998 that summarized existing literature regarding potential impacts to aquatic organisms from dredging operations (Reine and Clarke 1998). Fish entrainment rates varied widely among species and studies and were reported as ranging from <0.001 to 0.594 fish/cubic yard of material dredged.

The St. Louis District recently contracted a dredge monitoring study for the Chain of Rocks East Canal Levee Project (Blodgett 2010). The project involved the use of sand dredged from the main channel of the MMR for construction of a seepage berm on the Chain of Rocks Canal Levee. Because there was concern that dredging operations could entrain endangered pallid sturgeon in the project area, monitoring of dredged material was conducted to quantify impacts of dredging operations on the fish community. Approximately 800,000 cubic meters of material was dredged during the project, and fish entrainment monitoring was conducted during roughly 15% of the operation. No pallid sturgeon were captured during the study. However, nine shovelnose sturgeon and 38 other fish representing 6 species were captured during the study.

Aside from direct impacts from dredge entrainment, fish and wildlife could also be impacted directly by disposal of dredged material. Organisms in the vicinity of the disposal area could be affected by changes in water quality including increased suspended solids and could be covered by settling sediments. Increased suspended solids in the water column could cause abrasion of body and respiratory surfaces. Most mobile organisms in the vicinity of the disposal location, however, would likely avoid the area during dredging operations. Changes in water quality would be short-lived and localized in extent.

Recovery of fish and wildlife resources at the dredge and disposal location occurs over a period of weeks, months, or years, depending on the species in question (USACE 1983). Areas with unstable sediment such as those in the main channel of the MMR are much more likely to have associated fish and wildlife species more adapted to physically stressful conditions and, therefore, would be more likely to withstand stresses imposed by dredging and disposal and recover more quickly (USACE 1983).

In summary, the amount of dredging going forward would remain similar to what has been experienced recently. Dredging impacts would include potential entrainment of aquatic species as well as behavioral changes associated with noise and turbidity levels. Some mortality of individual fish and invertebrates would be anticipated. Overall impacts to the fish and invertebrate communities in the project area would be expected to be localized, minor, and short-term in nature.

Impacts of the Proposed Action on Fish and Wildlife

Dike Effects – The hydrodynamics around training structures are complex and vary greatly depending upon the type of training structure in question - and where it is located within the river channel. A traditional wing dike constructed perpendicular to flow and tied in to the river bank would be expected to deepen the adjacent navigation channel, cause a scour hole to develop at the dike tip, and cause sediment accretion downstream from the structure near the river bank. Shields (1995) studied 26 groups of traditional dikes in the Lower Mississippi River and determined that the aquatic volume and area of associated low-velocity habitat (important aquatic habitat) were reduced by 38% and 17%, respectively. Most of the changes occurred shortly after construction, and after initial adjustment, habitat area and volume fluctuated about a condition of dynamic equilibrium. As detailed in Section 3 above, dike construction on the MMR has, historically, caused a narrowing of the river planform over time due to this sediment accretion process followed by growth of terrestrial vegetation. However, the analysis of changes in river planform in the MMR recently conducted by the District (Brauer et al. 2005; Brauer et al. 2013) demonstrates that channel widths in the MMR appear to have reached a state of dynamic equilibrium where very little conversion to terrestrial habitat is occurring subsequent to river training structure placement.

Regardless of the specific configuration of the river training structures utilized, rock structures can provide improved habitat for fish by providing areas of reduced flow, a more diverse substrate, and additional cover. In addition, they can provide more suitable substrate for a wide variety of benthic organisms. Barko et al. (2004) found that species richness was greatest at wing dikes in the MMR for both adult and age-0 fishes when compared with main channel borders. However, they did find differences in species composition. Hartman and Titus (2009) studied dikes and reference sites on the Kanawha River, West Virginia and found that fish used dikes as much as or more than sites without dikes and that differences in taxonomic composition occurred. A study of larval fish use of dike structures on the Kanawha River found significantly higher capture rates of larval fish at dike sites than at reference sites (Niles and Hartman 2009). The difference in capture rates was attributed to reduced velocities provided by dikes. On the Upper Mississippi River, Madejczyk et al. (1998) found that fish abundance and diversity measures differed little among channel border habitat types in Pool 6, but significantly larger fish were present at locations with structure (wing dikes, woody snags) than at sites with bare shorelines. Riprapped shorelines had fish assemblages different from those in river sections containing only instream artificial rocky structures. Similar results were found in Pool 24 by Farabee (1986) where revetted main channel border sites had higher fish abundance than natural shorelines and larger revetment stone supported larger numbers of fish than small, tightly packed revetment stone. On the Lower Mississippi River, Pennington et al. (1983) found that the number of fish species taken from natural and revetted banks were similar. However, the relative abundance of individual species was different in the two habitats.

Limited sampling conducted by the St. Louis District at an offset dike field in the MMR (USACE 2012) showed an increase in bathymetric, flow, and sediment diversity from pre-construction to post-construction and showed similar fish community composition pre- and post-project. Schneider (2012) investigated fish community and habitat changes associated with chevron dike construction in the MMR St. Louis Harbor and found increased fish use and increased habitat diversity associated with chevrons dikes as compared to pre-construction conditions and open water control sites.

In summary, the dike is not expected to result in a loss of aquatic habitat due to sedimentation and conversion to terrestrial habitat. The structure is expected to increase bathymetric, flow, and sediment diversity in the immediate vicinity of the project. Fish response to these changes in habitat is difficult to predict quantitatively, but, based on prior studies, fish use of the area may increase after construction related disturbance ends.

Bendway Weir Effects - Bendway weirs are designed to reduce dredging requirements in river bends by controlling point bar development (Davinroy 1990). They consist of a series of low-level submerged dikes (top elevation >15 feet below the low water reference plane) constructed around the outer edge of a river bend. Each bendway weir is angled 30 degrees upstream of perpendicular to divert flow, in progression, toward the inner bank. The result is hydraulically controlled point bar development, reduced erosion of the outside bank, and a wider and safer navigation channel.

While providing benefits for navigation and channel maintenance, bendway weirs also provide complex habitat for macroinvertebrate and fish communities. Extreme main channel water depths found at outside bends without bendway weir fields are thought to be of little fisheries value (Baker et al. 1991). The bendway weir fields themselves provide a more heterogeneous environment than the surrounding homogenous sand substrate, resulting in greater species richness and diversity of benthic invertebrates (Ecological Specialists, Inc. 1997a, 1997b).

Hydroacoustic surveys of fishes were conducted by Kasul and Baker (1996) in four river bends of the MMR between Cairo, Illinois, and Cape Girardeau, Missouri (River Miles 2-50). Comparisons of fish density based on the hydroacoustic surveys suggested that bendway weirs increased the local abundance of fishes in affected areas of the river channel more than two-fold when compared to bends without bendway weirs.

While the presumed benefits of bendway weir fields on fish communities at outside bends are acknowledged by natural resource agency partners, there is also concern that there may be an associated negative impact on fish communities at the adjacent inside bend point bar. The effects of bendway weirs on point-bar fishery habitat were studied on the Lower Mississippi River (Schramm et al. 1998) by comparing the changes in late-falling and low-river stage electrofishing catch rates of prevalent fishes before (1994) and after (1996) installation of bendway weirs at Victoria Bend relative to the changes in catch rates of the same fishes at Rosedale Bend, a nearby reference site without bendway weirs. Large interyear variation in

catch rates was observed and, for most prevalent species, catch rates declined from 1994 to 1996 in sandbar habitats. However, significant declines in catch rates of prevalent species at Victoria Bend relative to changes in catch rates at the reference site were only noted for gizzard shad. Conversely, catch rates of goldeye, channel catfish, and flathead catfish at sandbar habitat during late-falling river stage significantly declined from 1994 to 1996 at Rosedale Bend while catch rates remained similar at Victoria Bend. Based on this limited study, the bendway weirs appeared to reduce gizzard shad abundance but, at certain river stages, may have improved habitat conditions for threadfin shad, goldeye, channel catfish, and flathead catfish.
In order to attempt to address resource agency partner concerns about the potential impacts of bendway weir fields on inside bend point bar habitat, the District completed a study in 2011 entitled "*Analysis of the Effects of Bendway Weir Construction on Channel Cross-Sectional Geometry*" (USACE 2011). The study utilized bathymetric data collected before and after bendway weir construction at 21 bendways in the MMR and one in Pool 24. The bathymetric data were used to analyze the cross-sectional changes in channel bed geometry associated with the bendway weirs. Area, width, wetted perimeter, and slope were compared pre- to post-bendway weir installation. The inner bend longitudinal slope was of particular interest due to concerns that the slopes were increasing, threatening shallow water habitat. The study showed that channel width at Low Water Reference Plane (LWRP) increased for 77% of the cross sections with an average increase of approximately 330 ft. The average slope decreased for 59% of all cross sections, with an average decrease of 1.27 ft. per 100 ft. The study concluded that bendway weirs are largely achieving their primary goal of widening the navigable portion of the channel without a serious detrimental effect on inside bar slopes.

The proposed placement of eight bendway weirs in the project area is expected to improve fish and macroinvertebrate habitat in the outside bend by providing substrate diversity, flow refugia, and increased macroinvertebrate colonization surface area. The impacts on fish and macroinvertebrate habitat on the inside bend opposite the bendway weirs are uncertain. Studies to date do not provide conclusive results for predicting fish or macroinvertebrate community response to bendway weir placement at adjacent inside bends.

Threatened and Endangered Species
A programmatic (Tier I) consultation (USACE 1999), conducted under Section 7 of the Endangered Species Act, considered the systemic impacts of the operation and maintenance of the 9-Foot Channel Navigation Project on the Upper Mississippi River System and addressed listed species as projected 50 years into the future (USFWS 2000). The consultation did not include individual, site specific project effects or new construction. It was agreed that site specific project impacts and new construction impacts would be handled under separate Tier II consultation. Although channel structure impacts were covered under the Tier I consultation, other site and species specific impacts could occur. As such, the District has prepared a Tier II Biological Assessment to determine the potential impacts of the project on federally threatened and endangered species. The Biological Assessment can be found at Appendix B.

As outlined in the Biological Assessments and associated USFWS correspondence (Appendix B) the determination has been made that the Proposed Action is not likely to adversely affect Indiana bat, gray bat, northern long-eared bat, fat pocketbook pearly mussel, sheepnose mussel, rabbitsfoot (mussel), and decurrent false aster. With respect to pallid sturgeon and the least tern, although adverse impacts associated with the proposed action have been avoided and minimized to the greatest extent possible and design modifications have been incorporated to provide habitat benefits, exact impacts remain unclear. However, the potential adverse effects of the project on pallid sturgeon and least tern are consistent with those anticipated in the programmatic Biological Opinion and the District has implemented the Reasonable and Prudent Measures and Terms and Conditions prescribed therein as appropriate for the project. Thus, the determination has been made that no significant impacts to pallid sturgeon and least tern are anticipated.

Although the bald eagle was removed from the federal list of threatened and endangered species in 2007, it continues to be protected under the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act (BGEPA). The BGEPA prohibits unregulated take of bald eagles, including disturbance. The U.S. Fish and Wildlife Service developed the National Bald Eagle Management Guidelines (USFWS 2007) to provide landowners, land managers, and others with information and recommendations regarding how to minimize potential project impacts to bald eagles, particularly where such impacts may constitute disturbance. No bald eagle nest trees are known to occur in the immediate vicinity of the project area at this time. If any nest trees are identified in the project area, the National Bald Eagle Management Guidelines will be implemented to minimize potential project impacts and appropriate coordination with the U.S. Fish and Wildlife Service will be conducted.

Socioeconomic Resources

Navigation

Impacts of the No Action Alternative on Navigation – With the No Action Alternative, periodic maintenance dredging activities would be expected to continue at a rate similar to recent history. Dredging costs in the project area over the past 12 years have averaged approximately $470,000 per year. These expenditures would be expected to continue in the future.

Impacts of the Proposed Action on Navigation – Implementation of the Proposed Action is expected to reduce the amount and frequency of dredging necessary in the project area. The estimated cost of the Proposed Action is approximately $1,350,000.

Historic and Cultural Resources

Impacts of the No Action Alternative on Historic and Cultural Resources – Continued dredging operations under the No Action Alternative are not anticipated to impact any known historic and cultural resources in the project area. Any undocumented historic and cultural resources that may have existed in the project area likely would have been destroyed by previous dredging activities. Future maintenance dredging under the No Action Alternative would likely occur in the same locations as previous dredging, and, therefore, would be unlikely to impact undocumented historic and cultural resources.

Impacts of the Proposed Action on Historic and Cultural Resources – All construction and modification work will be carried out via barge, without recourse to land access; therefore, any effects are limited to submerged cultural resources. Primary among these are historic period shipwrecks. The continual river flow and associated sedimentary erosion, deposition, and reworking make it highly unlikely that any more ephemeral cultural material remains on the river bed.

Given the features' construction method (with no land impact), the recent age of the landform, and the lack of any survey evidence for extant wrecks or other significant cultural resources, it is the District's opinion that the proposed undertaking will have no significant effect on cultural resources. Both the Illinois and Missouri State Historic Preservation Officers (SHPO) concurred that the proposed actions would not affect listed or eligible historic properties. A copy of the correspondence is included in Appendix C. If, however, cultural resources were to be encountered during construction, all work would stop in the affected area and further consultation would take place.

Twenty-eight federally recognized tribes affiliated with the St. Louis District were consulted and no objections to the project were raised. A copy of the consultation letter is included in Appendix C.

Cumulative Impacts

Council on Environmental Quality (CEQ) regulations define cumulative impacts as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time." (40 CFR §1508.7. In order to assist federal agencies in producing better cumulative impact analyses, CEQ developed a handbook, "Considering Cumulative Effects under the National Environmental Policy Act" (CEQ 1997). Accordingly, the Dogtooth Bend Phase 5 EA cumulative impact analysis generally followed the steps laid out by the handbook.

As summarized in Table 4 below, the cumulative impact analysis involved determining the incremental impact of the Project Alternatives on resources in the area in the context of all of the other past, present, and reasonably foreseeable future actions that might also impact each resource category. The analysis looked beyond the footprint of the project area and beyond the MMR to include impacts to the resources throughout the Upper Mississippi River watershed. Clearly the human environment in the MMR and the Upper Mississippi River watershed has been, and will continue to be, significantly impacted by a wide range of stressors. The Regulating Works Project, in combination with the other stressors throughout the watershed, has had past impacts, both positive and negative, on the human environment. However, this analysis is meant to characterize the incremental impact of the current action in the broader context of other actions affecting the same resources. Although past actions associated with the Regulating Works Project have impacted these resources, the current method of conducting business for the Project – involving partner agencies throughout the planning process, avoiding and minimizing impacts during the planning process, and utilizing innovative river training structures to provide habitat diversity while still providing benefits to the navigation system – has been successful in accomplishing the desired effect of avoiding significant environmental consequences. Although our understanding of the processes and stressors that bear upon the resources of the MMR continues to evolve, an equilibrium in habitat conditions appears to have been reached. Accordingly, no significant impacts to the human environment are anticipated for the Dogtooth Bend Phase 5 Construction Project.

Mitigation

Mitigation measures are used to avoid, minimize, or compensate for adverse impacts to environmental resources. The Dogtooth Bend Phase 5 Project has avoided and minimized adverse impacts throughout the project development process. No adverse impacts have been identified that would require compensatory mitigation.

Table 4. Summary of cumulative impacts.

Resource	Past Actions	Present Actions	Future Actions	No Action Alternative	Proposed Action
Stages	Flows and stages impacted by watershed land use changes, levee construction, mainline and watershed dam construction, consumptive water use, climate change	Continued impacts due to land use changes in watershed, consumptive water use, levee construction, climate change	Continued impacts due to land use changes in watershed, consumptive water use, levee construction, climate change	No impacts on stages anticipated	No impacts on stages anticipated at average and high flows. At low flows, current trend of decreasing stages expected to continue.
Water Quality	Increasing human populations and industrialization result in increased water quality problems. Establishment of Clean Water Act, NEPA, USEPA, state environmental agencies and associated regulations greatly improve conditions.	Continued population growth and development result in increased potential for water quality impacts. Continued regulation enforcement and societal recognition prevent water quality degradation.	Continued regulation enforcement and societal recognition. Continued population growth and development result in increased potential for water quality impacts.	Localized, temporary increase in suspended sediment concentrations at dredge material discharge sites	Localized, temporary increase in suspended sediment concentrations during construction activities
Air Quality	Increasing human populations and industrialization result in deterioration of air quality. Establishment of Clean Air Act, NEPA, USEPA, air quality standards, improve conditions. Attainment status in Project Area.	Continued population growth and development result in increased potential for air quality impacts. Continued regulation enforcement and societal recognition. Continued attainment status in Project Area.	Continued population growth and development result in increased potential for air quality impacts. Continued regulation enforcement and societal recognition. Continued attainment status in Project Area.	Occasional and ongoing minor and local impacts due to use of dredging equipment	Temporary, minor, local impacts to air quality due to one-time use of construction equipment

Table 4. (cont.)

Resource	Past Actions	Present Actions	Future Actions	No Action Alternative	Proposed Action
Fish and Wildlife (including threatened and endangered species)	Transformation of river system from natural condition to pooled lock and dam system; in MMR, loss of floodplain habitat due to levees, agriculture, urbanization; loss of natural river habitat – loss of dynamic habitat due to river channel being stabilized with dikes/revetment; dredging impacts; USACE, other federal, state, and private habitat restoration and land mgmt programs implemented to try to reverse habitat loss; introduction of exotic species/reduced native species biomass; implementation of innovative river training structures to provide habitat diversity; recognition of T&E species through Endangered Species Act; listing of multiple T&E species in MMR; implementation of District Biological Opinion Program and Avoid and Minimize Program	Maintenance of current habitat conditions due to maintenance of lock and dam system and maintenance of existing dikes/revetment; continued use of innovative river training structures to provide habitat diversity; habitat restoration and land mgmt through USACE, other federal, state, and private programs; habitat changes associated with recent and current innovative dike construction; maintenance of current floodplain habitat conditions due to continued agriculture use/ maintenance of existing levees/ urbanization; dredging impacts; native species continue to be impacted by exotic species; continued implementation of Biological Opinion Program	Continued maintenance of habitat conditions due to maintenance of lock and dam system and maintenance of existing dikes/revetment; continued use of innovative river training structures to provide habitat diversity; continued habitat restoration and land mgmt through USACE, other federal, state, and private programs; maintenance of current floodplain habitat conditions due to continued agriculture use/ maintenance of existing levees/ urbanization; new exotic species likely to be introduced; continued implementation of Biological Opinion Program and Avoid and Minimize Program	Entrainment of some fish and macroinvertebrates at dredge locations; avoidance of dredge and disposal areas by mobile organisms; some loss of fish and macroinvertebrates at disposal sites; may affect but not likely to adversely affect threatened and endangered species	Avoidance of sites during construction; no conversion of aquatic habitat to terrestrial; increased fish and macroinvertebrate use of structure locations due to increased bathymetric, flow, and substrate diversity; Uncertain impacts on fish and macroinvertebrates at inside bend opposite of proposed bendway weir locations. Resource agency concerns included, (1) potential impacts to flows in the existing side channel which could affect pallid sturgeon habitat, (2) potential impacts to the large gravel bar on the upper half of the island and the lower half of the island that provides a diversity of gradual sloping banks and shallow water habitat , which has been documented as being used by young of year pallid sturgeon, and (3) an overall reduction in the size of the island.

Table 4. (cont.)

Resource	Past Actions	Present Actions	Future Actions	No Action Alternative	Proposed Action
Navigation	1927 River and Harbor Act authorized USACE to provide 9-foot Nav channel on MMR; USACE transformed free-flowing Mississippi River system into navigable waterway with 37 lock and dam complexes, some dredging, dikes, revetment; growth of port facilities and inland waterways and traffic throughout Mississippi River system provided for movement of commodities with local, national, and international importance	Operation of lock and dam system continues; traditional and innovative stone dike, revetment construction, rock removal, and dredging continue to provide safe and dependable navigation channel; navigation continues to be an important part of local / national / international transportation and commerce activities	Operation of lock and dam system continues; traditional and innovative stone dike, revetment construction, rock removal, and dredging continue to provide safe and dependable navigation channel; navigation continues to be an important part of local / national / international transportation and commerce activities	Continued requirement for periodic maintenance dredging at rates similar to recent history.	Reduction in the amount and frequency of periodic maintenance dredging in the project area.
Historic and Cultural Resources	Historic and cultural resources subjected to natural processes and manmade actions (e.g., erosion, floodplain development); recognition of importance of historic and cultural resources through National Historic Preservation Act (and others)	Historic and cultural resources continue to be impacted by human activities as well as natural processes; continued societal recognition of importance of historic and cultural resources	Historic and cultural resources continue to be impacted by human activities as well as natural processes; continued societal recognition of importance of historic and cultural resources	Impacts to historic and cultural resources unlikely.	No known historic resources would be affected. Impacts to unknown historic and cultural resources unlikely.

5. Relationship of Proposed Action to Environmental Requirements

Federal Policy	Compliance Status
Bald Eagle Protection Act, 16 USC 668-668d	Full
Clean Air Act, 42 USC 7401-7542	Full
Clean Water Act, 33 USC 1251-1375	Partial 1*
Comprehensive Environmental Response, Compensation, and Liability Act, 42 USC 9601-9675	Full
Endangered Species Act, 16 USC 1531-1543	Full
Farmland Protection Policy Act, 7 USC 4201-4208	Full
Fish and Wildlife Coordination Act, 16 USC 661-666c	Full
Land and Water Conservation Fund Act, 16 USC 460d-461	Full
Migratory Bird Treaty Act of 1918, 16 USC 703-712	Full
National Environmental Policy Act, 42 USC 4321-4347	Partial 2*
National Historic Preservation Act, 16 USC 470 et seq.	Full
Noise Control Act, 42 USC 7591-7642	Full
Resource Conservation and Recovery Act, 42 USC 6901-6987	Full
Rivers and Harbors Act, 33 USC 401-413	Partial 1*
Water Resources Development Acts of 1986 and 1990	Full
Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (EO 12898)	Full
Floodplain Management (EO 11988 as amended by EO 12148)	Full
Prevention, Control, and Abatement of Air and Water Pollution at Federal Facilities (EO 11282 as amended by EO's 11288 and 11507)	Full
Protection and Enhancement of Environmental Quality (EO 11991)	Full
Protection and Enhancement of the Cultural Environment (EO 11593)	Full
Protection of Wetlands (EO 11990 as amended by EO 12608)	Full
Responsibilities of Federal Agencies to Protect Migratory Birds (EO 13186)	Full

1* Required permits will be sought during document review

2* Full compliance after submission for public comment and signing of FONSI

6. List of Preparers

Name	Role	Experience
Mike Rodgers	Project Manager	12 years, hydraulic engineering
Jasen Brown	Project Manager	12 years, hydraulic engineering
Eddie Brauer	Engineering Lead	12 years, hydraulic engineering
Kip Runyon	Environmental Lead	16 years, biology
Ken Cook	Environmental	20 years, biology
Kevin Slattery	HTRW	15 years, environmental science
Mark Smith	Historic and Cultural Resources	20 years, archaeology
Danny McClendon	Regulatory	27 years, regulatory compliance and biology
Keli Robertson	Legal Review	1 year USACE, 6 years private sector law

7. Literature Cited.

Baker J.A., K.J. Killgore, and R.L. Kasul. 1991. Aquatic habitats and fish communities in the lower Mississippi River. Aquatic Sciences. 3: 313–356.

Barko, V.A., D.P. Herzog, R.A. Hrabik, and J.S. Scheibe. 2004. Relationship among fish assemblages and main channel border physical habitats in the unimpounded Upper Mississippi River. Transactions of the American Fisheries Society, 133:2, 371-384.

Battle, J.M., J.K. Jackson, B.W. Sweeney. 2007. Annual and spatial variation for macroinvertebrates in the Upper Mississippi River near Cape Girardeau, Missouri. Fundamental and Applied Limnology. 168/1: 39-54.

Blodgett, N. 2010. Final Report: Monitoring of Dredged Material for Fish Entrainment with Special Emphasis on the Pallid Sturgeon, Phase III North Berms Dredging, Chain of Rocks Canal, Mississippi River, Madison County, IL. Prepared by Ecological Specialists, Inc. for the U.S. Army Corps of Engineers, St. Louis District, St. Louis, MO.

Brauer, E.J., R.D. Davinroy, L. Briggs, and D. Fisher. 2013. Draft Supplement to *Geomorphology Study of the Middle Mississippi River (2005)*. U.S. Army Corps of

Engineers, St. Louis District, Applied River Engineering Center, St. Louis, Missouri. 12 pp.

Brauer, E.J., D.R. Busse, C. Strauser, R.D. Davinroy, D.C. Gordon, J.L. Brown, J.E. Myers, A.M. Rhoads, and D. Lamm. 2005. Geomorphology Study of the Middle Mississippi River. U.S. Army Corps of Engineers, St. Louis District, Applied River Engineering Center, St. Louis, Missouri. 43 pp.

Davinroy, R. D. 1990. Bendway weirs, a new structural solution to navigation problems experienced on the Mississippi River. Permanent International Association of Navigation Congresses 69:5-18.

Ecological Specialists, Inc. 1997a. Macroinvertebrates associated with Carl Baer bendway weirs in the Mississippi River. In: Melvin Price Locks and Dam, Progress Report 1997 for Design Memorandum No. 24 Avoid and Minimize Measures. U.S. Army Corps of Engineers, St. Louis District.

Ecological Specialists, Inc. 1997b. Macroinvertebrates associated with bendway weirs at Mississippi River mile 30. In: Melvin Price Locks and Dam, Progress Report 1997 for Design Memorandum No. 24 Avoid and Minimize Measures. U.S. Army Corps of Engineers, St. Louis District.

Farabee, G. F. 1986. Fish species associated with revetted and natural main channel border habitats in Pool 24 of the Upper Mississippi River. North American Journal Fisheries Management 6: 504-508.

Galat, D. L., C. R. Berry, Jr., E. J. Peters, and R. G. White. 2005. Missouri River Basin. Pp. 427–480 in A. C. Benke and C. E. Cushing (eds.). Rivers of North America, Elsevier, Oxford.

Hartman, K.J. and J.L. Titus. 2009. Fish use of artificial dike structures in a navigable river. River Research and Applications. 26: 1170-1186.

Heitmeyer, M.E. 2008. An evaluation of ecosystem restoration options for the Middle Mississippi River Regional Corridor. Greenbrier Wetland Services Report 08-02, Advance, MO.

Huizinga, R.J. 2009. Examination of direct discharge measurement data and historic daily data for selected gages on the Middle Mississippi River, 1861-2008. U.S. Geological Survey Scientific Investigations Report 2009-5232. 60pp. (Available at http://pubs.usgs.gov/sir/2009/5232/)

Kasul, R. L., and J. A. Baker. 1996. Results of September 1995 hydroacoustic surveys of fishes in five reaches of the Middle Mississippi River (RM 2-50). Waterways Experiment Station Report prepared for the St. Louis District, U.S. Army Corps of Engineers.

Koel, T. M., and K. E. Stevenson. 2002. Effects of dredge material placement on benthic macroinvertebrates of the Illinois River. Hydrobiologia 474:229-238.

Madejczyk, J.C., N.D. Mundahl, and R.M. Lehtinen. 1998. Fish assemblages of natural and artificial habitats within the channel border of the Upper Mississippi River. American Midland Naturalist, Vol. 139, No. 2, pp. 296-310.

Munger, P.R., G.T. Stevens, S.P. Clemence, D.J. Barr, J.A. Westphal, C.D. Muir, F.J. Kern, T.R. Beveridge, and J.B. Heagler, Jr. 1976. SLD Potamology Study (T-1). University of Missouri-Rolla, Institute of River Studies, Rolla, Missouri.

Niles, J.M. and K.J. Hartman. 2009. Larval fish use of dike structures on a navigable river. North American Journal of Fisheries Management. 29: 1035-1045.

Pennington, C.H., J.A. Baker, and M.E. Potter. 1983. Fish populations along natural and revetted banks on the Lower Mississippi River. North American Journal of Fisheries Management 3: 204-211.

Reine, K., and D. Clarke. 1998. “Entrainment by hydraulic dredges–A review of potential impacts.” Technical Note DOER-E1. U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Sauer, J. 2004. Multiyear synthesis of the macroinvertebrate component from 1992 to 2002 for the Long Term Resource Monitoring Program. 2004. Final report submitted to U.S. Army Corps of Engineers from the U.S. Geological Survey, Upper Midwest Environment Sciences Center, La Crosse, Wisconsin, December 2004. Technical Report LTRMP 2004-T005. 31 pp. + Appendixes A–C.

Schneider, B. 2012. Changes in fish use and habitat diversity associated with placement of three chevron dikes in the Middle Mississippi River. M.S. thesis, Southern Illinois University Edwardsville.

Schramm, H.L., Jr., L.H. Pugh, M.A. Eggleton, and R.M. Mayo. 1998. Lower Mississippi River Fisheries Investigations 1996 Annual Report. Report prepared by the Mississippi Cooperative Fish and Wildlife Research Unit for the Lower Mississippi Valley Division, U.S. Army Corps of Engineers.

Shields, Jr., F. D. 1995. Fate of Lower Mississippi River habitats associated with river training dikes. Aquatic Conservation and Freshwater Ecosystems 5:97-108.

Simons, D.B., S.A. Schumm, and M.A. Stevens. 1974. Geomorphology of the Middle Mississippi River. Report DACW39-73-C-0026 prepared for the U.S. Army Corps of Engineers, St. Louis District, St. Louis, Missouri. 110 pp.

Theiling, C.H., C. Korschgen, H. De Haan, T. Fox, J. Rohweder, and L. Robinson. 2000. Habitat Needs Assessment for the Upper Mississippi River System: Technical Report. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin. Contract report prepared for U.S. Army Corps of Engineers, St. Louis District, St. Louis, Missouri. 248 pp.

UMRBC. 1982. Comprehensive Master Plan for the Management of the Upper Mississippi River System. Upper Mississippi River Basin Commission, Minneapolis, Minnesota. 193pp.

USACE. 1976. Environmental Statement, Mississippi River between the Ohio and Missouri Rivers (Regulating Works). U.S. Army Corps of Engineers, St. Louis District, St. Louis, Missouri.

USACE. 1983. Dredging and dredged material disposal. Engineer Manual 1110-2-5025. U.S. Army Corps of Engineers, Washington, DC.

USACE. 1999. Tier I of a two tiered Biological Assessment - Operation and Maintenance of the Upper Mississippi River Navigation Project within St. Paul, Rock Island, and St. Louis Districts. Mississippi Valley Division, Vicksburg, MS.

USACE. 2011. Analysis of the effects of bendway weir construction on channel cross-sectional geometry. U.S. Army Corps of Engineers, St. Louis District, St. Louis, MO.

USACE. 2012. Devils Island offset dikes: pre- and post-construction monitoring completion report. U.S. Army Corps of Engineers, St. Louis District, St. Louis, MO.

USACE. 2013. Waterborne commerce of the United States. U.S. Army Corps of Engineers Navigation Data Center Waterborne Commerce Statistics Center. http://www.navigationdatacenter.us/wcsc/wcsc.htm . Accessed 21 August 2013.

USFWS. 2000. Biological opinion for the operation and maintenance of the 9-foot navigation channel on the Upper Mississippi River System. U. S. Department of the Interior, Fort Snelling, Minnesota.

USEPA. 2013. U. S. Environmental Protection Agency green book nonattainment areas for criteria pollutants as of July 31, 2013. http://www.epa.gov/airquality/greenbk/ . Accessed 13 August 2013.

USFWS. 2007. National Bald Eagle Management Guidelines. U.S. Fish and Wildlife Service, Arlington, VA.

Watson, C.C., D.S. Biedenharn, and C.R. Thorne. 2013a. Analysis of the impacts of dikes on flood stages in the Middle Mississippi River. Journal of Hydraulic Engineering 139:1071-1078.

Watson, C.C., R.R. Holmes, and D.S. Biedenharn. 2013b. Mississippi River streamflow measurement techniques at St. Louis, Missouri. Journal of Hydraulic Engineering 139:1062-1070.

WEST Consultants, Inc. 2000. Upper Mississippi River and Illinois Waterway Navigation Feasibility Study – Cumulative Effects Study, Volumes 1-2. Prepared by WEST Consultants, Inc. for the U.S. Army Corps of Engineers, Rock Island District, Rock Island, Illinois

DRAFT FINDING OF NO SIGNIFICANT IMPACT (FONSI)
REGULATING WORKS PROJECT
DOGTOOTH BEND PHASE 5
MIDDLE MISSISSIPPI RIVER MILES 40.0-20.0
ALEXANDER COUNTY, IL, MISSISSIPPI AND SCOTT COUNTIES, MO

I. In accordance with the National Environmental Policy Act, I have reviewed and evaluated the documents concerning the Regulating Works, Dogtooth Bend Phase 5 Construction Project, Alexander County, Illinois, and Scott and Mississippi Counties, Missouri. As part of this evaluation, I have considered:

a. Existing resources and the No Action Alternative.
b. Impacts to existing resources from the Proposed Action.

II. The project alternatives have been studied for physical, biological, cultural, and socioeconomic effects. My evaluation of the project has resulted in the following conclusions:

a. The project would address repetitive dredging conditions in the project area. This would be accomplished by the construction of eight bendway weirs and one dike.

b. No significant impacts to natural resources, fish and wildlife resources and federally threatened or endangered species are anticipated from this project. There would be no appreciable degradation to the physical environment (e.g., stages, air quality, and water quality) due to the project.

c. The proposed project would have no adverse effect upon historic properties or archaeological resources.

d. The "no action" alternative was evaluated and determined to be unacceptable as repetitive dredging expenditures would continue.

III. Based on the evaluation and disclosure of impacts contained within the Environmental Assessment, I find no significant impacts to the human environment are likely to occur as a result of the Proposed Action. The Proposed Action has been coordinated with the appropriate resource agencies and the public, and there are no significant unresolved issues. Therefore, an Environmental Impact Statement will not be prepared prior to proceeding with the proposed Regulating Works, Dogtooth Bend Phase 5 Construction Project, Alexander County, Illinois and Mississippi and Scott Counties, Missouri.

________________________ ___________________________________

(Date)

CHRISTOPHER G. HALL
COL, EN Commanding

DRAFT ENVIRONMENTAL ASSESSMENT

WITH

UNSIGNED FINDING OF NO SIGNIFICANT IMPACT

REGULATING WORKS PROJECT
DOGTOOTH BEND PHASE 5
MIDDLE MISSISSIPPI RIVER MILES 40.0-20.0
ALEXANDER COUNTY, IL
MISSISSIPPI AND SCOTT COUNTIES, MO

DECEMBER 2013

APPENDICES

Appendix A. Summary of Research on the Effects of River Training Structures on Stages

With implementation of the Proposed Action, stages at average and high flows both in the vicinity of the project area and on the Middle Mississippi River are expected to be similar to current conditions. An abundance of research has been conducted analyzing the impacts of river training structures on water surfaces dating to the 1940s. This research has analyzed historic gage data, velocity data, and cross sectional data. Physical and numerical models have also been used to determine the effects of dikes on water surfaces. A summary of research on the topic is detailed below. Based on an analysis of this research by the Corps and other external reviewers, the District has concluded that river training structures do not affect water surface elevations at higher flows.

The first study specifically addressing the effect of river training structure construction on water surfaces was conducted during the extreme high water of June and July 1935 (Ressegieu 1952). This study was prompted by the differences in observed streamflow for equal stages following the transfer of streamgaging responsibility from the Corps to the United States Geological Survey (USGS) in March 1933. The study addressed the accuracy of the standard equipment and method of observation between the two agencies. Similar simultaneous streamflow studies were conducted between 1935 and 1948. In 1952, the results of all of the studies were analyzed and it was concluded that, on average, the discharges measured by the Corps generally exceeded those measured by the USGS by zero percent at mean stage to slightly more than ten percent at high stages. Another conclusion of Ressegieu (1952) was that "the reduction in floodway capacity was not an actual physical reduction but an apparent reduction caused by a discrepancy in the accuracy of measuring streamflow by older methods and equipment." The conclusions by Ressegieu (1952) were analyzed along with new information and confirmed by Watson et al. (2013a).

The topic of the effect of dikes on flood heights was revisited in the 1960's when it was determined through an analysis of changes in the stage/discharge relationship over time that "the contraction by permeable dikes has had a negligible effect on the increase in flood heights" (Monroe 1962). The change in stages for higher flows was attributed to the construction and raising of levees on the Middle Mississippi River.

Munger et al. (1976) studied the changes in hydraulics on the Mississippi River resulting from river confinement by levees and the construction of river training structures. As was the case in previous studies using gage data, the reliability of early discharge data collected by the Corps was brought into question. In a study of velocity, stage and discharge data, Munger et al. (1976) concluded that "generalizations about the effect of dikes on stage-discharge relations are not justified." When examining cross section shape and velocity distributions at the St. Louis gage it was observed that there had been no striking changes in cross-section shape or velocity distributions at the section between 1942 and 1973.

Dyhouse (1985, 1995) found through numerical and physical modelling that published discharges for historic floods, including 1844 and 1903, were greatly overestimated. Dyhouse concluded that the use of early discharge data collected by the Corps including historic peak flood discharges in conjunction with streamflow measurements by the USGS will result in incorrect conclusions.

To update ongoing evaluations of the physical effects of river training structures, the Corps initiated a new study on the possible effect of these structures on water surfaces. This series of studies included an analysis of past research, an analysis of the available gage data on the MMR, an analysis of historic measurement technique and instrumentation and its effect on the rating curve, specific gage analysis, numerical and physical modelling. In addition to the research conducted by the Corps, the St. Louis District engaged with external technical experts in the fields of river data collection, river engineering, geomorphology hydraulics and statistics.
In a review of historic streamflow data collected prior to the USGS, Watson & Biedenharn (2010) determined that pre-USGS data should be omitted for the following reasons (1) It has been confirmed through simultaneous measurement comparisons that there is much uncertainty in the historic data due to differences in methodology and equipment (2) there is much uncertainty with respect to the location of the discharge range (3) there is insufficient measured data at the higher flow ranges to produce reliable specific gage records (4) the homogeneous data set containing all discharges collected by the USGS provides an adequate long-term, consistent record of the modern-day river system including periods of significant dike construction.
In their analysis, Watson & Biedenharn (2010) studied the specific gage records at the three rated gages on the MMR: St. Louis, Chester and Thebes. The analysis for Thebes was omitted in this paper due to the effect of backwater from the Ohio River. For each streamgage studied, the specific gage record was analyzed and compared with a record of river training structure construction for a reach extending 20 river miles downstream. All data used in their study was collected by the USGS and retrieved from their website.

Bankfull stage at the St. Louis gage is +15 feet Low Water Reference Plane (LWRP) with a corresponding discharge of approximately 500,000 cfs. Flows below 400,000 cfs are contained within the top bank and flows above 700,000 cfs are well above the top-bank elevation. The time period 1933-2009 was studied. The top elevation of training structures in this reach was between +15 and +18 feet LWRP and all structures are completely submerged at discharges exceeding 280,000 cfs. In their analysis, Watson and Biedenharn (2010) found a statistically significant slightly decreasing trend in streamflows below 200,000 cfs. In streamflows between 300,000 cfs 500,000 cfs a statistically significant horizontal trend in stages was observed. At 700,000 cfs there was a trend in stages that was not statistically significant. The slight upward trend in stages at 700,000 cfs had considerable variability in the data and was strongly influenced by the 1993 flood.

Bankfull stage at the Chester gage is +27 feet LWRP with a corresponding discharge of approximately 420,000 cfs. The time period 1942-2009 was studied. The top elevation of navigation structures in this reach was +17 to +19 feet LWRP and all structures are completely submerged at discharges exceeding 280,000 cfs. The only statistically significant trend found was a statistically significant slightly decreasing trend for streamflows below 100,000 cfs. There was no trend for 200,000 and 400,000 cfs. There was a slightly increasing trend at 300,000 cfs. For both overbank flows, 500,000 cfs and 700,000 cfs, there were slight increasing trends.
After a closer examination of the specific gage trends it was apparent that the long term trends for both St. Louis and Chester were not continuous and there was a shift in stages that occurred in the early 1970’s. When the record was broken into pre- and post-1973 sections different trends were observed. Prior to 1973 at all gages studied, there were no increasing trends for any of the flows. Post-1973 there were no increasing stage trends for within-bank flows at any of the

gages. A slightly increasing stage trend occurred for overbank flows of 500,000 cfs and 700,000 cfs at the Chester gage. A majority of the construction of river training structures on the Middle Mississippi was performed prior to 1973.

In conjunction with the specific gage record, Watson & Biedenharn (2010) and Watson et al. (2013) analyzed the record of training structure construction including an analysis of the top elevation of the structures. The typical top elevation of the structures was between 10-16 feet below the top bank. Since the top elevation is so far below top-bank elevations, the most dramatic impacts of the structures should be in the low to moderate stages below top bank where the specific gage analysis revealed decreasing or no trends.

Watson & Biedenharn (2010) concluded that, "based on the specific gage records, there has been no significant increase in stages for within-bank flows that can be attributable to river training structure construction. Any increase in overbank flood stages may be the result of levees, floodplain encroachments, and extreme hydrologic events; and cannot be attributed to river training structures based solely on specific gage records."

Huizinga (2009) conducted a specific gage analysis using the direct step method on only data collected by the USGS for the gages at St. Louis and Chester. Similar to Watson & Biedenharn (2010), an apparent decrease of stage with time for smaller, in bank discharges was observed at both the St. Louis and Chester gages. This decrease in stage was attributed to the construction of river training structures and/or a decrease in sediment load available for transport on the Mississippi River due to the construction of reservoirs on the main stem tributaries of the Mississippi River, particularly the Missouri River.

Huizinga (2009) found a slight increase in stage over time for higher flows at both St. Louis and Chester over the entire period of record. The transitional discharge was 400,000 cfs and 300,000 cfs for the St. Louis and Chester gages respectively. These discharges correspond to stages of +25 feet LWRP at St. Louis and +22 feet LWRP at Chester. At these stages the navigation structures are submerged by 7-10 feet. Huizinga (2009) attributed the slight increase in out of bank flows to the construction of levees and the disconnection of the river to the floodplains. Similar to Watson & Biedenharn (2010), Huizinga (2009) observed a shift occurring in the out of bank flows in the mid-1960s and attributed it to the completion of the Alton to Gale levee system which paralleled the entire Middle Mississippi River.

In an analysis of cross sectional data collected at the St. Louis and Chester gages it was found that although the shape of the cross section had changed, the cross sectional area for moderate (400,000 cfs) and high (600,000 cfs) flows remained relatively constant throughout the period of record. The construction of river training structures immediately upstream of the Chester gage provided a case study on the effect of the absence and construction of structures on the cross section over time. Prior to the construction of the structures, the channel thalweg repeatedly shifted between the left and right banks. Following the construction of the structures, the cross sections displayed much less variability. An overall stabilizing effect of the structures was seen on the cross section for discharges of 100,000 cfs and 400,000 cfs. The cross sectional area for the first and last measurements of the period of record remained similar despite the river training structure construction upstream for all discharges.

Huizinga (2009) conducted a study of all rating curves developed for St. Louis and Chester, including those developed prior to 1933 by the Corps. When comparing daily values from the Corps from 1861-1927 to the original USGS rating in 1933 there appeared to be an abrupt change in the upper end of the ratings used before 1933. When these daily values developed by the Corps were "adjusted" to compensate for the overestimation of Corps discharge measurements detailed in the simultaneous discharge measurement studies between the Corps and USGS the adjusted daily discharge values plotted in line with the original USGS rating (A). This study is further evidence of the overestimation of early discharges.

The Iowa Institute of Hydraulic Research (IIHR) at the University of Iowa performed a series of hydrodynamic simulations of a recently constructed chevron field and dike extension using the United States Bureau of Reclamation Sedimentation and River Hydraulics Two-Dimensional (SRH-2D) modelling software (Pitrowski et al. 2012). Simulations studied the impact of the construction on water surfaces and the magnitude of natural variation on water surfaces. The results indicated that structures did not cause significant differences in reach-scale water surface elevations. The simulations also found that the differences in pre- and post- construction water surface elevations were less than the differences resulting from natural variability.

A physical sediment transport model at the University of Illinois, Urbana-Champaign was used to test the effect of submerged dikes and dike fields on water surfaces (Brauer 2013). The study tested flows and stages along a rating curve from ½ bankfull to a flow with a 0.5% annual chance exceedance. The study concluded that the magnitude of the effect of dikes on water surfaces was smaller than other variables that can influence the stage/discharge relationship and decreased with increasing flow/submergence. The study also found that there was no direct cumulative effect for up to four structures.

Other reach scale numerical and physical models studying the effect of river training structures on water surfaces include USACE (1996) which used a Hydrologic Engineering Center (HEC-2) model used to analyze pre- and post- construction water surface elevations for the Nebraska Point Dike field on the Lower Mississippi River. For each cross section analyzed, the dike field construction lowered water surface elevations and reduced overbank discharges for the 50%, 20%, and 10% annual chance exceedance events. Xia (2009) used an Adaptive Hydraulics Modeling (ADH) model to study the changes in water surface resulting from the construction of a dike field. In this fixed bed analysis, Xia found that changes in water surface elevation due to the dikes was greatest at average flows and decreased with increasing and decreasing river flow. Azinfar and Kells (2007) developed a multiple function model to predict the drag coefficient and backwater effect of a single spur dike in a fixed bed. This study concluded that increasing submergence levels resulted in a decreasing backwater effect.

In a moveable bed model study conducted to develop structural alternatives for a power plant on the Minnesota River, Parker et al. (1988) measured water surface changes from a baseline for a series of dikes and determined that construction of the structures had a negligible effect on flood stages compared to calibration values. Yossef (2005) used a 1:40 scale fixed bed physical model of the Dutch River Waal to study the morphodynamics of rivers with groynes including their effect on water surface. Yossef found that on the River Waal, the effect of groynes decreased with increasing submergence. It was also observed that the maximum possible water level reduction of the design flood (378,000 cfs) by lowering all of the groynes in the system was 0.06 meters.

There is research supporting the claims that dike construction has resulted in an increase in flood heights of up to 16 feet. The first study proposing this link was Stevens et al. (1975) who proposed that the combination of river training structures constricting the main channel and levees isolating the main channel from its floodplain resulted in increased stages for flood discharges. Through the use of historic streamgage data, Belt (1975) arrived at the same conclusion. The source data, methodology and analysis used by these studies were questioned by Stevens (1976), Dyhouse (1976) Strauser & Long (1976) and Westphal & Munger (1976). By comparing the trends in stage and streamflow measurements for rivers with and without river training structures, Criss & Shock (2001) concluded that stages have increased over time on rivers due to the construction of river training structures.

Pinter et al. (2001) used specific gage analyses to study the changes in stage and discharge relationships on the Middle Mississippi River and concluded that the presence of river training structures has increased roughness and resulted in an increase in flood stages.
One limitation of specific gage analysis is that it can only be performed on gages with a discharge record. Jemberie et al. (2008) developed a refined specific gage approach to overcome this limitation by developing “synthetic discharges” at stage only gages. The synthetic discharges are created by interpolating discharge values at nearby gages to create a stage-discharge relationship at stage only gages. Jemberie et al. (2008) also formulated a continuous specific gage time series for large, rare discharges by using “enhanced interpolation.” The results of the refined specific gage study were that stages that correspond to flood discharges increased substantially at all stations consistent with what was documented by Pinter (2001). Remo & Pinter (2007) used a 1-D unsteady Hydrologic Engineering Center River Analysis System (HEC-RAS) model (“retro-model”) to assess the magnitude and type of changes in flood stages associated with 20th century river engineering. The “retro-model” used historic hydrologic and geospatial pre-USGS data to establish baseline roughness conditions. The baseline was then compared to present day hydraulic conditions to determine the changes in roughness as a result of engineering modifications. The results from the “retro-model” showed an increase in flood stages similar to those observed by Pinter (2001) and Jemberie et al. (2008). The increase in water surfaces found by Stevens et al. (1975), Belt (1975), Criss & Shock (2001), Pinter et al. (2001) and Jemberie et al. (2008) are all driven by the difference in measured discharges between the Corps and USGS. When the homogenous data set of only discharges collected by the USGS are used, the trends shown in the aforementioned studies is not seen. In Remo & Pinter (2007) the proposed link between river training structures and water surfaces is tied to an increase in channel roughness between the two time periods modeled. The increase in roughness found by Remo & Pinter (2007) was a consequence of using an inaccurate stage-discharge relationship (rating curve) developed using early Corps discharges and comparing it to a more accurate rating curve developed using USGS data.

As part of the updated analysis of the effect of river training structures on water surfaces, experts in river engineering and statistics from the Corps and other external experts including the USGS and academia studied all of the available research on the topic. There is an abundance of research conducted by the Corps and others spanning over 80 years on the topic. The conclusions of recent research proposing a link between river training structures and flood heights relies on dubious assumptions, source data and methodology. The results of the analysis of existing research have lead to the conclusion that river training structures do not have an impact on water surfaces for higher flows.

REFERENCES

Azinfar, H. and Kells, J.A. (2007). "Backwater effect due to a single spur dike". Can. J. Civ. Eng., 34. 107-115.

Belt, C.B. 1975. The 1973 flood and man's constriction of the Mississippi River. *Science.* 189(4204), 681-684.

Brauer, E.J. 2009. The limitations of using specific gage analysis to analyze the effect of navigation structures on flood heights in the Middle Mississippi River. Vienna, Austria, Proceedings of the 4th international congress of Smart Rivers '21. Sept 6-9. p156-163.

Brauer (2012) The effect of river training structures on flood heights on the Middle Mississippi River. San Jose, Costa Rica. Proceedings of the 6th edition of the International Conference on Fluvial Hydraulics. Sept 5-7. CRC Press.

Brauer, E.J. 2013. The Effect of Dikes on Water Surfaces in a Mobile Bed. MS Thesis. University of Illinois, Urbana-Champaign.

Criss, R.E., & Shock, E.L. 2001. Flood enhancement through flood control. *Geology*. 29(10), 875-878

Dyhouse. 1976. Discussion of "Man-induced changes of Middle Mississippi River". *Journal of the waterways, harbors, and costal engineering division. Proceedings of the American Society of Civil Engineers.* 102(WW2). 277-279

Dyhouse, G.R. 1985. Comparing flood stage-discharge data- Be Careful! In Hydraulics and Hydrology in the Small Computer Age: Proceedings of the Specialty Conference. Waldrop WR (ed.) American Soc. Of Civil Engineers Hydraulics Divison: New York; 73-78

Dyhouse, G.R. 1995. Effects of Federal Levees and Reservoirs on 1993 Flood Stages in St. Louis. Washington, DC. National Research Council, Transportation Research Board, Record No. 1483. 7p.

Huizinga, R.J. 2009. Examination of measurement and historic daily data for several gaging stations on the Middle Mississippi River, 1861-2008. U.S. Geologicial Survey Scientific Investigations Report 2009-5232. 60p. (Also available at http://pubs.usgs.gov/sir/2009/5232/)

Jemberie, A.A., Pinter, N., and Remo, J.W.F. 2008. Hydrologic history of the Mississippi and Lower Missouri Rivers based on a refined specific-gage approach. *Hydrologic Processes.* 22:7736-4447. Doi:10.1002/hyp.7046

Monroe, R.H. 1962. U.S. Geological Survey, unpublished data

Munger, P.R., Stevens, G.T., Clemence, S.P., Barr, D.J., Westphal, J.A., Muir, C.D., Kern, F.J., Beveridge, T.R., and Heagler, Jr., J.B. 1976. SLD Potamology Study (T-1). University of Missouri-Rolla, Institute of River Studies, Rolla, Missouri.

Parker, G., Garcia, MH, Joannesson, J. and Okabe, K. (1988). Model Study of the Minnesota River near Wilmarth Power Plant, Minnesota, Project Report No. 284, Saint Anthony Falls Hydraulic Laboratory, University of Minnesota.

Pinter, N.R., Thomas, and J.H. Wlosinski. 2001. Flood-hazard assessment on dynamic rivers. *Eos: Transactions of the American Geophysical Union*, 82(31). 333-339

Piotrowski, J.A., Young, N.C., Weber, L.J. 2012. Supplemental Investigatoin of the Influence of River Training Structures on Flood Stages From River Mile 179.5 to 190.0 of the Middle Mississippi River. Submitted to the U.S. Army Corps of Engineers, St. Louis, Missouri.

Remo, J.W.F. and N. Pinter. 2007. Retro-modeling of the Middle Mississippi River. *Journal of Hydrology*. Doi:10.1016/j.hodrol.2007.02.008

Ressegieu, F.E. 1952. Comparative discharge measurements, Mississippi River by USGS and Corps of Engineers. St. Louis District, U.S. Army Corps of Engineers.

Samaranayake, V.A. 2009. The statistical review of three papers on specific gage analysis. Report to U.S. Army Corps of Engineers, St. Louis District.

Stevens, M.A., Simons, D.B., and Schumm, S.A. 1975. Man-induced changes of the Middle Mississippi River. *Journal of the Waterways Harbors and Coastal Engineering Division, Proceedings of the American Society of Civil Engineers*, 101(WW2). 119-133.

Stevens, G.T. 1976. Discussion of "Man-induced changes of Middle Mississippi River". *Journal of the waterways, harbors, and costal engineering division. Proceedings of the American Society of Civil Engineers.* 102(WW2). 280

Strauser, C.N. and N.C. Long. 1976. Discussion of "Man-induced changes of Middle Mississippi River". *Journal of the waterways, harbors, and costal engineering division. Proceedings of the American Society of Civil Engineers.* 102(WW2). 281-282

U.S. Army Corps of Engineers. 1942. Mississippi River flood discharge capacity. Prepared by U.S. Army Engineer District, St. Louis.

USACE (1996). Barfield Bend Potomology Study Update, Mississippi River, Hydraulics and Hydrology Branch.

Watson, C.C. and Biedenharn, D.C. 2010. Specific gage analyses of stage trends on the Middle Mississippi River. Report to U.S. Army Corps of Engineers, St. Louis District.

Watson, C.C., R.R. Holmes, D.S. Biedenharn. 2013a. Mississippi River Streamflow Measurement Techniques at St. Louis, Missouri. J. Hydraulic Engineering: 139:1062-1070

Watson, C.C., D.S. Biedehnarn, C.R. Thorne. 2013b. Analysis of the Impacts of Dikes on Flood Stages in the Middle Mississippi River. J. Hydraulic Engineering. 139:1071-1078.

Westphal, J.A. and P.R. Munger. 1976. Discussion of “Man-induced changes of Middle Mississippi River”. *Journal of the waterways, harbors, and costal engineering division. Proceedings of the American Society of Civil Engineers.* 102(WW2). 283-284

Xia, R. (2009). “Using computational model- ADH to evaluate relationship of water surface elevation to wing dikes”. World Environmental and Water Resource Congress. ASCE.

Yossef, M.F (2002). The effect of groynes on rivers: Literature review. Delft Cluster project no. 03.03.04.

Yossef, M.F.M., (2005), Morphodynamics of rivers with groynes, Delft University Press, Delft

Appendix B. Biological Assessment

APPENDIX B
TIER II BIOLOGICAL ASSESSMENT:
DOGTOOTH BEND PHASE 5
RIVER MILES 40-20
ALEXANDER COUNTY, ILLINOIS
SCOTT AND MISSISSIPPI COUNTIES, MISSOURI
ON THE
MIDDLE MISSISSIPPI RIVER SYSTEM

U.S. Army Corps of Engineers
St. Louis District
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December 2013

1. Programmatic Endangered Species Compliance

A programmatic (Tier I) consultation(USACE 1999a), conducted under Section 7 of the Endangered Species Act, considered the systemic impacts of the operation and maintenance of the 9-Foot Channel Navigation Project on the Upper Mississippi River System and addressed listed species as projected 50 years into the future (USFWS 2000). The consultation did not include site specific project effects or new construction. It was agreed that site specific project impacts and new construction impacts would be handled under separate Tier II consultation. Although channel structure impacts were covered under the Tier I consultation, other site and species specific impacts may occur. As such, the Regulating Works, Dogtooth Bend Phase 5 Construction Project (Dogtooth Bend Phase 5 Project) requires a Tier II consultation.

2. Project Authority

The project is authorized under the Regulating Works Project that was authorized by River and Harbor Acts beginning in 1881. The project purpose is to provide a safe and dependable navigation channel. It consists of a navigation channel 9-feet deep and not less than 300 feet wide with additional width in bends, from the mouth of the Ohio River to the mouth of the Missouri River, a distance of approximately 195 miles. Project improvements are achieved by means of dikes, revetment, construction and maintenance dredging, and rock removal.

3. Project Need

The purpose of the Dogtooth Bend Phase 5 Project is to enhance the aquatic habitat diversity and flow dynamics within the reach, specifically the Bumgard Island project is located between Mississippi River miles (MRM) 34.2 and 30.7.

Dredging in the Mississippi River is commonly used to provide required navigation dimensions of depth, width, alignment, or a combination thereof. In the case of this study, repetitive channel maintenance dredging was required in four different areas along the reach (Figure 1). The sandbar located along the Right Descending Bank (RDB) near River Mile (RM) 35.00 to 31.80 has grown in size between RM 34.50 to 33.80 and RM 32.90 to 31.50. Bumgard Island, located along the Left Descending Bank (LDB) between RM 31.00 to 29.00, has also grown causing shoaling between RM 31.40 to 30.60. Downstream of Bumgard Island on the LDB, shoaling has occurred between RM 28.90 to 27.20. On average, dredging in this reach has been required nearly every year from 2001 to 2012. During this twelve year period, the following total estimates of dredge material quantities in cubic yards (cy) and costs were calculated:

- RM 34.50 to 33.80: 315,516 cy at a cost of $408,414
- RM 32.90 to 31.50: 946,670 cy at a cost of $2,328,255
- RM 31.40 to 30.60: 639,035 cy at a cost of $973,146
- RM 28.90 to 27.20: 1,201,738 cy at a cost of $1,930,945.

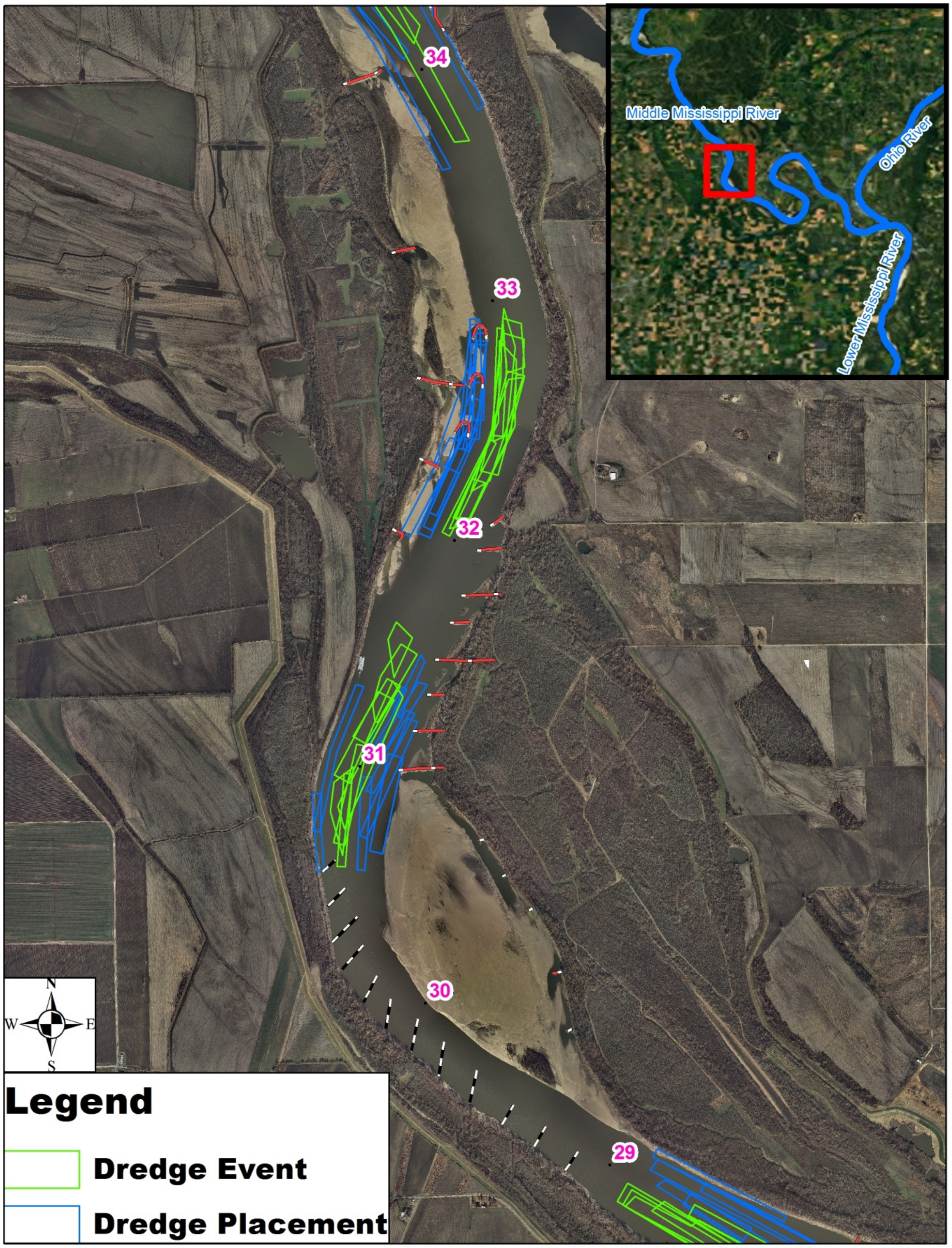

Figure 1. Repetitive dredging areas in the vicinity of the project since 2000.

The Proposed Action consists of construction of two bendway weirs near RM 34.00, four bendway weirs near RM 32.00, a dike at RM 31.60 and two bendway weirs near RM 31.00. (Table 1, Figure 2). Specifically, the Bumgard project would involve the following actions in order to attain the desired conditions:

Table 1. Proposed Action and potential results.

Location by river mile	Work to be completed	Potential Physical Results (from Hydraulic Sediment Response Model)
34.2 (L)	Construct bendway weir 600 feet long -Top elevation of the Weir will be 277.5 (-20 Low Water Reference Plane).	The bendway weirs at RM 34.2, 34.1, 32.5, and 32.2 (L) improved the width of the channel at RM 34.00, and reduced the sedimentation in the channel between RM 31.9-31.6. Dike 31.6 (R) provided more constriction to the channel, thus, contributing to the sediment reduction. Weirs 30.8 & 30.7(R) helped the flow transition from the crossing into the bend at RM 31.00. The design alternative also showed great improvement in the channel depth between RM 29.00 - 27.20 although there was some slight sedimentation. The channel was also wider along the bendway weir field between RM 30.6 - 29.15 without affecting Bumgard Island or its side channel.
34.1 (L)	Construct bendway weir 600 feet long -Top elevation of the weir will be 277.25	
32.5 (L)	Construct bendway weir 400 feet long -Top elevation of the weir will be 281.1 (-15 Low Water Reference Plane).	
32.4 (L)	Construct bendway weir 500 feet long -Top elevation of the weir will be 281.0	
32.3 (L)	Construct bendway weir 650 feet long -Top elevation of the weir will be 280.9	
32.2 (L)	Construct bendway weir 500 feet long -Top elevation of the weir will be 280.8	
31.6 (R)	Construct Dike 300 ft long -Top elevation of the dike will be 310.4 (+15 Low Water Reference Plane).	
30.8 (R)	Construct bendway weir 160 ft long -Top elevation of the weir will be 274.75 (-20 Low Water Reference Plane).	
30.7(R)	Construct bendway weir 162 ft long -Top elevation of the weir will be 274.65	

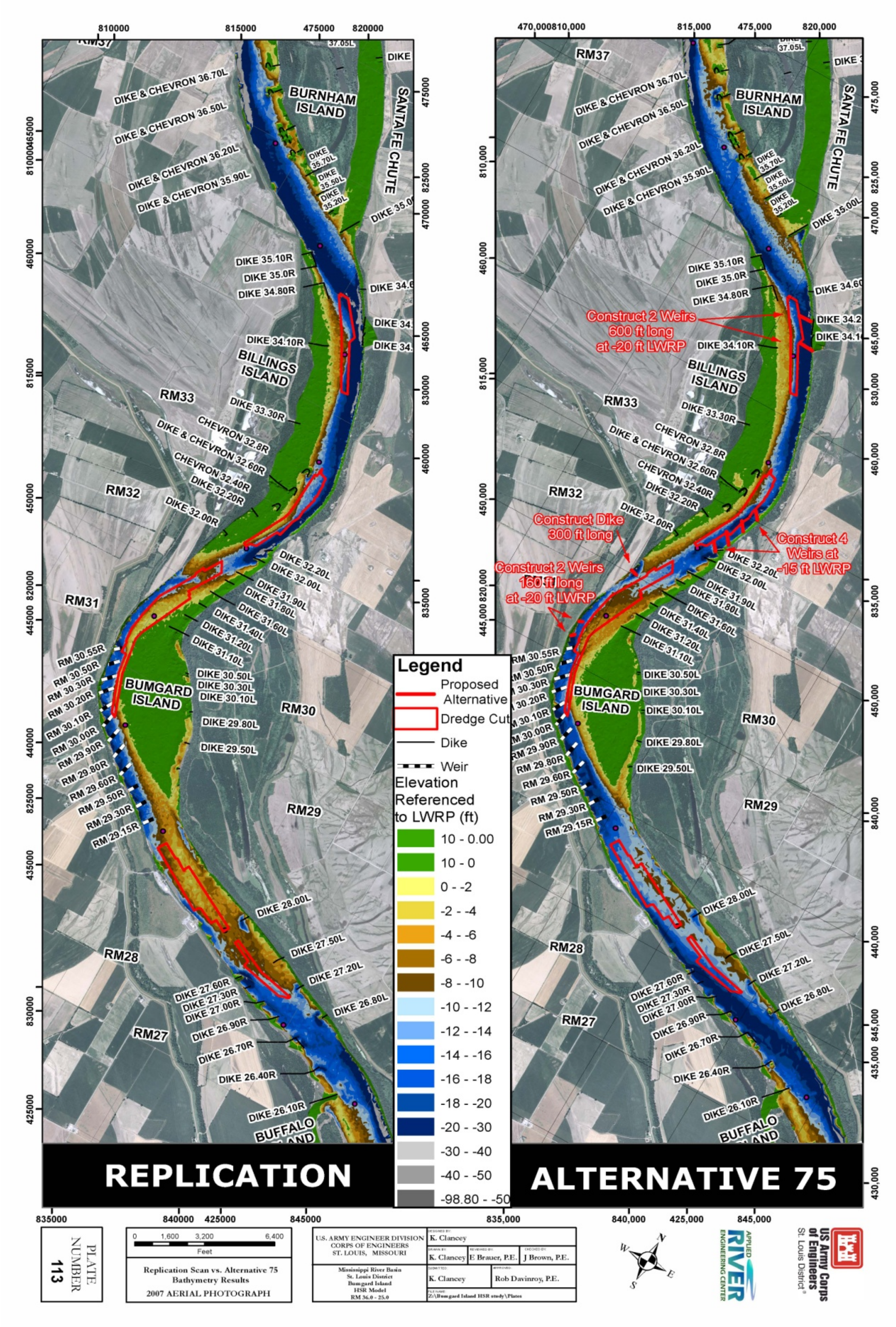

Figure 2. Features associated with the Proposed Action

4. Species Covered in this Consultation:

This species list is in agreement with the Mississippi and Scott Counties, Missouri, and Alexander County, endangered species lists posted on U.S Fish and Wildlife Service (USFWS) Region 3 IPaC website as of December 2013. https://ecos.fws.gov/ipac/

Species	**Fed Status**	**Habitat**
Indiana bat (*Myotis sodalis)*	Endangered	Hibernacula in caves and mines; Maternity and foraging habitat - small stream corridors with well developed riparian woods; upland and bottomland forests
Gray bat *(Myotis grisescens)*	Endangered	Caves and mines; forages over rivers and reservoirs adjacent to forests
Northern long-eared bat (*Myotis septentrionalis*)	Candidate	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. Roosts and forages in upland forests during spring and summer.
Least tern (interior population) (*Sternula antillarum*)	Endangered	Large rivers - nest on bare alluvial and dredge spoil islands
Pallid sturgeon (*Scaphirhynchus albus*)	Endangered	Mississippi and Missouri Rivers
Fat pocketbook pearly mussel (*Potamilus capax*)	Endangered	Large Rivers in slow-flowing water in mud and sand.
Sheepnose *(Plethobasus cyphyus)*	Endangered	Shallow areas in larger rivers and streams
Rabbitsfoot (*Quadrula cylindrical cylindrical*)	Threatened	Small to large rivers in sand and gravel
Decurrent false aster (*Boltonia decurrens*)	Threatened	Recently disturbed areas within wet prairies, shallow marshes, and shores of open rivers, creeks and lakes

5. Impact Assessment

The proposed project includes construction of eight weirs and one dike between river miles 34.0 and 31.0. Dikes and bendway weirs are prominent channel regulating features common in main channel habitats in the MMR. They are used to concentrate flow in the main channel in order to reduce the need for dredging. One of the goals of this project, and alternative selection, was to minimize adverse impacts to the sand island habitat on Bumgard Island.

As stated in the 2000 Biological Opinion, “Bendway weirs were developed to inhibit point-bar establishment in bends and channel crossings and to reduce the need for dredging in these areas. They consist of a series of submerged dikes (usually 15-20 ft. below the low water reference plane) generally constructed around the outer edge of a river bend. Bendway weirs have also been utilized in other depositional areas in the MMR. Each dike is angled 30 degrees upstream of perpendicular to divert flow, in progression, towards the inner bank. The result is hydraulically controlled point bar development and reduced channel down cutting throughout the bend” (USFWS 2000, USACE 2011).

Indiana Bat – The range of the Indiana bat includes much of the eastern half of the United States, including Missouri and Illinois. Indiana bats migrate seasonally between winter hibernacula and summer roosting habitats. Winter hibernacula include caves and abandoned mines. Females emerge from hibernation in late March or early April to migrate to summer roosts. During summer, the Indiana bat frequents the corridors of small streams with well-developed riparian woods, as well as mature upland forests. It forages for insects along stream corridors, within the canopy of floodplain and upland forests, over clearings with early successional vegetation (old fields), along the borders of croplands, along wooded fencerows, and over farm ponds in pastures. Females form nursery colonies under the loose bark of trees (dead or alive) and/or cavities, where each female gives birth to a single young in June or early July. A maternity colony may include from one to 100 individuals. A single colony may utilize a number of roost trees during the summer, typically a primary roost tree and several alternates. Some males remain in the area near the winter hibernacula during summer months, but others disperse throughout the range of the species and roost individually or in small numbers in the same types of trees as females. Disturbance and vandalism, improper cave gates and structures, natural hazards such as flooding or freezing, microclimate changes, land use changes in maternity range, and chemical contamination are the leading causes of population decline in the Indiana bat (USFWS 2000, 2004).

Modification measures resulting in aquatic habitat improvement should contribute to the species' forage base. Dike and weir construction is anticipated to be primarily performed by river-based equipment and has minimal potential to affect Indiana bats because forested habitats would not be affected. This project would not result in the destruction of any riparian habitat and construction is scheduled to occur in the winter months when Indiana bats are not present. Thus, the proposed dike and weir construction "may affect but are not likely to adversely affect" the Indiana bat.

Gray Bat – The gray bat is listed as endangered and occurs in several Illinois and Missouri counties where it inhabits caves both summer and winter. This species forages over rivers and reservoirs adjacent to forests. No caves would be impacted by the proposed action; therefore, this project would have “no effect” on the gray bat.

Northern long-eared bat - The northern long-eared bat is a federal candidate for listing as an endangered species throughout its range (Federal Register 2 October 2013). The northern long-eared bat is sparsely found across much of the eastern and north central United States, and all Canadian provinces from the Atlantic Ocean west to the southern Yukon Territory and eastern British Columbia. Northern long-eared bats spend winter hibernating in large caves and mines. During summer, this species roosts singly or in colonies underneath bark, in cavities, in crevices of both live and dead trees. Foraging occurs in interior upland forests. Forest fragmentation, logging and forest conversion are major threats to the species. One of the primary threats to the northern long-eared bat is the fungal disease, white-nose syndrome, which has killed an estimated 5.5 million cave-hibernating bats in the Northeast, Southeast, Midwest and Canada. No caves or upland forests would be impacted by the proposed action; therefore, this project would have “no effect” on the northern long-eared bat.

Least Tern – The least tern is a colonial, migratory waterbird which resides and breeds along the Mississippi River during the spring and summer. Least terns arrive on the Mississippi River from late April to mid-May. Reproduction takes place from May through August, and the birds migrate to the wintering grounds in late August or early September (USACE 1999b). Sparsely vegetated portions of sandbars and islands are typical breeding, nesting, rearing, loafing, and roosting sites for least terns along the MMR. Nests are often at higher elevations and well removed from the water’s edge, a reflection of the fact that nesting starts when river stages are relatively high (USACE 1999b). In alluvial rivers, sandbars are dynamic channel bedforms. Individual sandbars typically wax and wane over time as fluvial processes and the construction of river engineering works adjust channel geometry according to varying sediment load and discharge. There is limited data on site fidelity for Mississippi River least terns. Given the highly dynamic bed and planform of the historic river, ability to return to previously used colony sites is not likely a critical life history requirement. The availability of sandbar habitat to least terns for breeding, nesting, and rearing of chicks from 15 May to 31 August is a key variable in the population ecology of this water bird. Only portions of sandbars that are not densely covered by woody vegetation and that are exposed during the 15 May to 31 August period are potentially available to least terns (USACE 1999b). The size of nesting areas and the number of nests within a colony depend on water levels and the extent of associated sandbars (Sidle and Harrison 1990). Sandbars have a greater possibility of colonization by least terns if river levels remain low during the breeding season. Smith and Renken (1991) found that sites were more likely to be used by interior least terns in the Mississippi River Valley adjacent to Missouri if sites were continuously exposed for at least 100 days during the breeding season. A 1999 report (USACE 1999b) estimated that there were approximately 20,412 acres of nonvegetated sandbar habitat above the MMR low water reference plane (LWRP). About 4,975 acres (111 ac/RM) were located between the Mouth of the Ohio and Thebes Gap (RM 0-45) and 15,437 acres (103 ac/RM) between Thebes Gap and the Mouth of the Missouri River (RM 45-195). Currently, reoccurring nesting is known at Marquette Island (RM 50.5), Bumgard Island (RM 30), and Brown’s Bar (RM 24.5-23.5) (Jones 2009, USFWS 2004). Some nesting attempts have also been made at Ellis Island (RM 202), however these are not considered to be reoccurring. While the Mississippi River appears to have a large amount of sandbar habitat, much of this habitat is not likely available to least terns for nesting and may not be located near suitable foraging habitats (USFWS 2009).

Least terns are almost exclusively piscivorous (Anderson 1983), preying on small fish, primarily minnows (Cyprinidae). Prey size appears to be a more important factor determining dietary composition than preference for a particular species or group of fishes (Moseley 1976, Whitman 1988, USACE 1999b). Fishing occurs close to the nesting colonies and may occur in both shallow and deep water, in main stem river habitats or backwater lakes or overflow areas. Radiotelemetry studies have shown that terns will travel up to 2.5 miles to fish (Sidle and Harrison 1990, USACE 1999b). Along the Mississippi River, individuals are commonly observed hovering and diving for fish over current divergences (boils) in the main channel, in areas of turbulence and eddies along natural and revetted banks, and at “run outs” from floodplain lakes where forage fish may be concentrated (USACE 1999b).

As noted above, least terns are known to nest on Bumgard Island (Jones 2009, Keith McMullen St. Louis District USACE pers. comm.). In a meeting with the Missouri Department of Conservation (MDC), Illinois Department of Natural Resources (IDNR), the U.S Fish & Wildlife Service, Fisheries and Ecological Services (USFWS), and industry groups on 18 September, 2013, (and after many prior group discussions with the natural resource agencies and industry), a design for the placement of the rock structures was chosen to minimize the impacts to Bumgard Island and hence the least tern habitat. In order to comply with the programmatic Biological Opinion and implementation of the Reasonable and prudent Measures and Terms and Conditions prescribed therein (USFWS 2000), it was agreed upon that Alternative 75 achieved the best balance of the study’s goals, including pre- and post construction monitoring, and was the recommended alternative.

However, it was also agreed upon that Alternative 75 could have some impacts to the Bumgard Island complex especially regarding side channel flows and loss of island habitat. Concerns were expressed that there could be possible decreases or increases in the amount of flow in the side channel that the model could not detect with the proposed alternatives. Under present conditions flow is maintained in the side channel for most of the year making it accessible to fish and keeping the island isolated from the bank - important components of least tern habitat. The combination of the proposed weirs and dike in the model have shown a slight reduction in the size of the island and a loss of the shallow water habitat on the downstream end of the island.

As the recommended course of action, Alternative 75 would be proposed for construction during late FY14 or early FY15, pending completion of required environmental compliance review. The reach would be physically monitored prior to and extensively after construction, to evaluate hydrologic and geomorphic changes. After the river has had time to react to the structures, the group would evaluate the reach again to determine if adverse changes to side channel flows and/or losses to island habitat were taking place. If so, a re-evaluation of the alternatives would be required. Details of the hydraulic sediment response model (HSR) that led to the formation and analysis of alternatives can be found at:

http://mvs-wc.mvs.usace.army.mil/arec/Reports_HSR_Model.html

Although adverse impacts to the least tern associated with this project have been avoided and minimized to the greatest extent possible and design modifications have been incorporated to provide habitat benefits, the least tern may still be adversely affected by the project. However, the adverse effects of the project on the least tern are consistent with those anticipated in the programmatic Biological Opinion and the District has implemented the Reasonable and Prudent Measures and Terms and Conditions prescribed therein as appropriate for the project.

Pallid Sturgeon – The estimated population of pallid sturgeon in the MMR ranges between 4900 and 1600 individuals (Garvey et al. 2009). Pallid sturgeon are very rare relative to shovelnose sturgeon in the MMR (a 1:82 ratio), whereas at Baton Rouge, Louisiana the ratio is 1:6. Threats to population recovery of pallid sturgeon include limited rearing and nursery habitat and loss of mature female adults. Pallids apparent non-reproductive habitat includes wing dikes with sandy substrate, and areas with contrasting flow velocities, complexes of island point bars, and side channels. During low water as in late summer, pallids are found more in the main channel. Reproductive habitat includes the Chain of Rocks area, known gravel bars in the MMR, tributary confluences and side channels (Peterson and Herzog 1999, Garvey et al. 2009).

According to Garvey et al. (2009), adult pallid habitat for foraging and holding station in flow in the MMR is adequate and related primarily to the wing dike areas, although all habitats have been occupied. Hypothetically, some wing dikes may mimic natural depositional areas adjacent to the main channel. Pallid sturgeon need main channel conditions, island areas that provide an ecotone between flow with deposition. These areas cause an accumulation of insects and small insectivorous fish that facilitate foraging, growth and ultimately reproductive condition. The availability and quality of reproductive habitat for spawning and production of offspring in the MMR is unknown (Sheehan and Heidinger 2001, Garvey et al. 2009). If adult pallid sturgeon densities increase, wing dikes creating preferred habitat will likely become limited and habitat restoration that creates needed main-channel conditions should be a priority (Garvey et al. 2009).

It is the position of the U.S. Fish and Wildlife Service (2000) that over time, channel training structures have adversely affected pallid sturgeon by altering the quality and quantity of habitats in the MMR to which the species is adapted (e.g., braided channels, irregular flow patterns, flood cycles, extensive microhabitat diversity, and turbid waters). According to the Service, this loss of habitat has reduced pallid sturgeon reproduction, growth, and survival by (1) decreasing the availability of spawning habitat; (2) reducing larval and juvenile pallid sturgeon rearing habitat; (3) reducing the availability of seasonal refugia, and (4) reducing the availability of foraging habitat (USFWS 2000). Additionally, some authors believe that loss of habitat contributes to the hybridization of pallid and shovelnose sturgeon (Carlson et al. 1985, Keenlyne et al. 1993, Campton et al. 1995, USFWS 2000). The Service also asserts that these habitat changes have also reduced the natural forage base of the pallid sturgeon, and is another likely contributing factor in its decline (Mayden and Kuhajda 1997, USFWS 2000). The Service states that channel training structures have also altered the natural hydrograph of the MMR by contributing to higher water surface elevations at lower discharges than in the past and to a downward trend in annual minimum stages (Simons et al. 1974, Wlosinski 1999, USFWS 2000). Thus, as a result, previously aquatic habitats are now dry at low discharges (Wlosinski 1999). According to the Service, this has potentially reduced the availability of pallid sturgeon spawning habitat through the loss of habitat complexity (USFWS 2000). Confinement and simplification of the main channel likely reduce habitat features such as instream islands and side channels (Garvey et al. 2009).

Construction activities may result in short-term adverse effects for pallid sturgeon. Activities that impact any existing deepwater habitat may result in displacement of pallid sturgeon. Disruption of existing sand bar habitat may impact foraging habitat. However, these adverse effects are expected to occur at a local, individual dike/weir scale. By completing regulating works projects with incorporated modifications and limitations to increase habitat diversity at the scale of the dike/weir field, long-term beneficial effects for pallid sturgeon should result. The creation of scour holes is expected to create additional larval/juvenile rearing habitat and seasonal refugia, and improve forage food production (USFWS 2004). It is the position of the St. Louis District that short-term adverse impacts that may occur are limited, and the long-term impacts associated with reduced dredging and increased habitat diversity, which is expected as a consequence of river training structure modification and dike placement, are predicted to be beneficial to pallid sturgeon.

As above for the least tern, in a meeting with the MDC, IDNR, the USFWS, and industry groups on 18 September, 2013, (and after many prior group discussions with the natural resource agencies and industry), a design for the placement of the rock structures was chosen to minimize the impacts to the Bumgard Island complex including adjacent and localized pallid sturgeon habitat. In order to comply with the programmatic Biological Opinion and implementation of the Reasonable and prudent Measures and Terms and Conditions prescribed therein (USFWS 2000), it was agreed upon that Alternative 75 achieved the best balance of the study's goals, including pre- and post construction monitoring, and was the recommended alternative.

However, as mentioned above for the least tern, it was also agreed upon that Alternative 75 could also potentially cause some adverse impacts to the Bumgard Island complex, especially regarding side channel flows which currently provides suitable habitat for the pallid sturgeon. Concerns were expressed that there could be possible decreases or increases in the amount of flow in the side channel that the model could not detect with the proposed alternatives. Under present conditions flow is maintained in the side channel for most of the year making it accessible to fish and keeping the island isolated from the bank. The island complex also provides a variety of habitats that are used not only by adult and juvenile pallid sturgeon, but also many other species. There is a large gravel bar on the upper half of the island and the lower half of the island that provides a diversity of gradual sloping banks and shallow water habitat (limiting habitat in the Mississippi), which has been documented as being used by young of year pallid sturgeon. The combination of the proposed weirs and dike in the model has shown a slight reduction in the size of the island and a loss of the shallow water habitat on the downstream end of the island.

As the recommended course of action, Alternative 75 would be proposed for construction during late FY14 or early FY15, pending completion of required environmental compliance review. The reach would be physically monitored prior to and extensively after construction, to evaluate hydrologic and geomorphic changes. After the river has had time to react to the structures, the group would evaluate the reach again to determine if adverse changes to side channel flows and/or losses to island habitat were taking place. If so, a re-evaluation of the alternatives would be required. Details of the hydraulic sediment response model (HSR) that led to the formation and analysis of alternatives can be found at:

http://mvs-wc.mvs.usace.army.mil/arec/Reports_HSR_Model.html

Although adverse impacts to pallid sturgeon associated with this project have been avoided and minimized to the greatest extent possible and design modifications have been incorporated to provide habitat benefits, pallid sturgeon may still be adversely affected by the project. However, the adverse effects of the project on the pallid sturgeon are consistent with those anticipated in the programmatic Biological Opinion and the District has implemented the Reasonable and Prudent Measures and Terms and Conditions prescribed therein as appropriate for the project.

Fat pocketbook pearlymussel - The fat pocketbook pearly mussel is listed as endangered has has only been found occasionally within the Mississippi River, although currently there are no known viable populations (USFWS 1989). Collection records suggest that this mussel prefers lotic habitat with firm substrate (USFWS 1989). Because of its rarity and preferred habitat which does not normally exist within the construction area the project would have “no effect” on the fat pocketbook pearlymussel.

Sheepnose mussel – The sheepnose is listed as a federally endangered species and occurs in the Meramec River in Jefferson County, Missouri. This species inhabits gravel and mixed sand and gravel habitats in medium to large rivers (USFWS 2003).

The sheepnose is thought to be extant in five pools (3, 5, 15, 20 and 22) in very low numbers. In the Upper Mississippi River, the sheepnose is an example of a rare species becoming rarer. Despite the discovery of juvenile recruitment in Mississippi River Pool 7, the sheepnose population levels in the Upper Mississippi River appear to be very small and of questionable long-term viability given the threats outlined below. The sheepnose and other mussel populations in the Upper Mississippi River are seriously threatened by zebra mussels. Even if some level of sheepnose recruitment was documented, the status of this species in the Mississippi is highly jeopardized, with imminent extirpation a distinct possibility (USFWS 2003). This project could potentially benefit this species by providing some of its necessary habitat features, i.e. shallow shoal habitats and flow refugia. This project “may affect, but is unlikely to adversely affect” the sheepnose mussel.

Rabbitsfoot - The rabbitsfoot is listed as federally threatened (SSFWS 2009). It is primarily an inhabitant of small to medium sized streams and some larger rivers. It usually occurs in shallow water areas along the bank and adjacent runs and shoals with reduced water velocity and in moderately compacted gravel and sand substrate. It has also been documented in mixed cobble and gravel substrate. It feeds on the bottom of a stream, lake, or pond but rarely burrows into the substrate. In small streams, this species is associated with bars or gravel and cobble near fast current, and it has also been found in eddies along the periphery of midstream currents. Spawning occurs between May and July. Threats include siltation, drainage, pollution, zebra mussels, impoundments, livestock, and poor water quality. This species is not known historically to occur in the Mississippi River; therefore, this project will have “no effect” on the rabbitsfoot mussel.

Decurrent false aster – The decurrent false aster is presently known from scattered floodplain localities from the confluence of the Mississippi River with the Illinois River south to Madison County, Illinois (USFWS 1990a). Its natural habitat was lake shores and stream banks with abundant light. Populations presently grow in natural habitat, but are more common in disturbed lowland areas where they appear to be dependent on human activity for survival (USFWS 1990). Because this species is not known from the project area, the project “may affect, but is not likely to adversely affect” the decurrent false aster.

6. Literature Cited

Anderson, E.A. 1983. “Nesting Productivity of the interior or Least Tern in Illinois.” Unpublished Report. Cooperative Wildlife Research Laboratory, Southern Illinois University, Carbondale, Illinois, 19 pp.

Campton, D.E., A.I. Garcia, B.W. Bowen, and F.A. Chapman. 1995. Genetic Evaluation of Pallid, Shovelnose and Alabama Sturgeon (*Scaphirhynchus albus*, *S. platorhynchus*, and *S. suttkusi*) Based on Control Region (D-loop) Sequences of Mitochondrial DNA. Report from Dept. of Fisheries and Aquatic Sciences, Univ. of Florida, Gainesville, Florida.

Carlson, D.M., W.L. Pflieger, L. Trial, and P.S. Haverland. 1985. Distribution, biology, and hybridization of *Scaphirhynchus albus* and *S. platorhynchus* in the Missouri and Mississippi Rivers. Environmental Biology of Fishes. 14:51-59.

Garvey, J.E., E.J. Heist, R.C. Brooks, D.P. Herzog, R. A. Hrabik, K.J. Killgore, J. Hoover, and C. Murphy. 2009. Current status of the pallid sturgeon in the Middle Mississippi River: habitat, movement, and demographics. Saint Louis District, US Army Corps of Engineers. http://fishdata.siu.edu/pallid

Jones, K. H. 2009. Population Survey of the Interior Least Tern on the Mississippi River from Cape Girardeau, Missouri to Baton Rouge, Louisiana. Under contract with Choctaw Transportation Company, Inc. Dyersburg, Tennessee. 18 pp. with appendix.

Keenlyne, K.D., L.K. Graham, and B.C. Reed. 1993. Natural hybrids between two species of Scaphirhynchinae sturgeon. U.S. Fish and Wildlife Service, Pierre, South Dakota. Unpubl. Report.

Mayden, R.L., and B.R. Kuhajda. 1997. Threatened fishes of the world: *Scaphirhynchus albus* (Forbes and Richardson, 1905) (Acipenseridae). Environmental Biology of Fishes. 48:420-421.

Moseley, L.J. 1976. “Behavior and Communication in the Least Tern (Sterna albifrons).” Ph.D. Dissertation, University of North Carolina, Chapel Hill. 164 pp.

Petersen, M., and D. Herzog. 1999. Open River Field Station Report: Young-of-the-year pallid sturgeon collected in the Mississippi River. Missouri Department of Conservation, Long Term Resource Monitoring Station, Cape Girardeau, Missouri.

Sheehan, R.J., R.C. Heidinger, K. Hurley, P.S. Wills, M.A. Schmidt. 1998. Middle Mississippi River pallid sturgeon habitat use project: Year 3 Annual Progress Report, December 1998. Fisheries Research Laboratory and Department of Zoology, Southern Illinois University at Carbondale, Carbondale, Illinois.

Sheehan, R.J., and R. C. Heidinger. 2001. Middle Mississippi River Pallid Sturgeon Habitat Use Project. In: Upper Mississippi River Basin, Mississippi River Missouri and Illinois, Progress Report 2000, Design Memorandum Number 24, Avoid and Minimize Measures, June 2001.

Sidle, J.G. and W.F. Harrison, 1990. Recovery Plan for the Interior Population of the Least Tern (Sterna antillarum). U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 90 pp. (1)

Simons, D.B., S.A. Schumm, and M.A. Stevens. 1974. Geomorphology of the Middle Mississippi River. Report DACW39-73-C-0026 prepared for the U.S. Army Corps of Engineers, St. Louis District, St. Louis, Missouri. 110 pp.

Smith, J. W., and R. B. Renken. 1991. Least tern nesting habitat in the Missisippi River valley adjacent to Missouri. Journal of Field Ornithology 62:497-504.

USACE (U.S. Army Corps of Engineers). 1999a. Tier I of a Two Tiered Biological Assessment. Operation and Maintenance of the Upper Mississippi River Navigation Project within St. Paul, Rock Island, and St. Louis Districts. U.S. Army Corps of Engineers. April 1999.

USACE (U.S. Army Corps of Engineers). 1999b. Biological Assessment, Interior Population of the Least Tern, Sterna Antillarum, Regulating Works Project, Upper Mississippi River (River Miles 0-195) and Mississippi River and Tributaries Project, Channel Improvement Feature, Lower Mississippi River (River Miles 0-954.5, AHP). U. S. Army Corps of Engineers, Mississippi Valley Division/Mississippi River Commission, Vicksburg, Mississippi, December 1999.

USACE (U.S. Army Corps of Engineers). 2011 Analysis of the Effects of Bendway Weir Construction on Channel Cross-Sectional Geometry 34 pp.

USFWS (U.S. Fish and Wildlife Service). (1989). "A Recovery Plan for the Fat Pocketbook Pearly Mussel *Potamilus canax* (Green 1832) ," U.S. Fish and Wildlife Service. Atlanta, Georgia. 22 pp.

USFWS (U.S. Fish and Wildlife Service). 1990. Decurrent False Aster Recovery Plan. Twin Cities, Minnesota: U.S. Fish and Wildlife Service. 26 pp.

USFWS (U.S. Fish and Wildlife Service). 2000. Biological Opinion for the Operation and Maintenance of the 9-Food Navigation Channel on the Upper Mississippi River System, May 15, 2000.

USFWS (U.S. Fish and Wildlife Service). 2003. Status Assessment Report for the sheepnose, *Plethobasus cyphyus*, occurring in the Mississippi River system (U.S. Fish and Wildlife Service Regions 3, 4, and 5)

USFWS (U.S. Fish and Wildlife Service). 2004. Final Biological Opinion for the Upper Mississippi River-Illinois Waterway System Navigation Feasibility Study, August 2004.

USFWS (U.S. Fish and Wildlife Service). 2009. Section 7 Consultation: Operation and Maintenance of the Upper Mississippi River 9-Foot Channel [Online Source] Available: Interior Least Tern http://www.fws.gov/midwest/endangered/section7/tern.html

USFWS (U.S. Fish and Wildlife Service). 2009. Rabbitsfoot Candidate Form http://www.fws.gov/midwest/endangered/clams/pdf/rabbistfoot_cand_elevation.pdf.

Whitman, P.L. 1988. Biology and Conservation of the Endangered Interior Least Tern: A Literature Review. Biological Report 88(3). U.S. Fish and Wildlife Service, Division of Endangered Species, Twin Cities, Minnesota.

Wlosinski, J. 1999. Hydrology. Pages 6-1 to 6-10 in USGS, ed., Ecological Status and Trends of the Upper Mississippi River System. USGS Upper Midwest Environmental Sciences Center, LaCrosse, Wisconsin. 241 pp.

Appendix C. Correspondence

Appendix D. Clean Water Act Section 404(b)(1) Evaluation