FINAL ENVIRONMENTAL ASSESSMENT

WITH

FINDING OF NO SIGNIFICANT IMPACT

REGULATING WORKS PROJECT

MOUTH OF THE MERAMEC
MOSENTHEIN REACH – IVORY LANDING, PHASE V
RM 160 – 162.5

MONROE COUNTY, ILLINOIS
ST. LOUIS COUNTY, MISSOURI
ON THE
MIDDLE MISSISSIPPI RIVER SYSTEM

JUNE 2015

US Army Corps
of Engineers
St. Louis District

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1. Purpose of and Need for Action

The Congress of the United States, through the enactment of a series of Rivers and Harbors Acts beginning in 1824, authorized the Secretary of the Army, by and through the U.S. Army Corps of Engineers St. Louis District (District), to provide a safe and dependable navigation channel, currently 9 feet deep and not less than 300 feet wide, with additional width in the bends as required, on the Middle Mississippi River (MMR).[1] The MMR is defined as that portion of the Mississippi River that lies between its confluence with the Ohio and the Missouri rivers (hereinafter referred to as the Project; Figure 1). This ongoing Project is also commonly referred to as the Regulating Works Project. The Regulating Works Project utilizes bank stabilization and sediment management to maintain bank stability and ensure adequate navigation depth and width. Bank stabilization is achieved by revetments, while sediment management is achieved by river training structures, i.e. dikes. Other activities performed to obtain the navigation channel are rock removal and construction dredging. The Project is maintained through dredging and any needed maintenance to already constructed features. Therefore, both regulating works structures and dredging are all part of the overall Regulating Works Project. The long-term goal of the Project, as authorized by Congress, is to provide a sustainable and safe navigation channel and reduce federal expenditures by alleviating the amount of annual maintenance dredging and the occurrence of vessel accidents through the construction of regulating works. Therefore, pursuant to the Congressionally authorized purpose of the Project, the District continually monitors areas of the MMR that require frequent and costly dredging to determine if a long-term sustainable solution through regulating works is reasonable.

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[1] Congress originally authorized the project of improving navigation of the Mississippi River from the mouth of the Missouri to New Orleans in the Rivers and Harbors Act dated May 24, 1824, by the removal of trees that were endangering the safety of navigating the river. In the Rivers and Harbors Act dated June 10, 1872, Section 2, Congress mandated that an examination and/or survey be completed of the Mississippi River between the mouth of the Missouri River and the mouth of the Ohio River, providing the first Congressional action to define this portion of the Mississippi River as distinct from the rest of the Mississippi River. Congress authorized the specific improvement of the Mississippi River between the mouth of the Missouri River and the mouth of the Ohio River in the Rivers and Harbors Act dated March 3, 1873. Between 1874-1892, Congress expanded this section of the Mississippi River to include that portion between the mouth of the Missouri and the mouth of the Illinois, but in the Rivers and Harbors Act dated July 13, 1892, Congress removed this additional section of the river and once again referred to it as the Mississippi River between the mouth of the Ohio River and the mouth of the Missouri River. In the Rivers and Harbors Act dated June 25, 1910, Congress provided exactly how this Project was to be carried out by authorizing the construction, completion, repair, and preservation of "[i]mproving [the] Mississippi River from the mouth of the Ohio River to and including the mouth of the Missouri River: Continuing improvement in accordance with the plan adopted in [1881], which has for its object to eventually obtain by regularization works and by dredging a minimum depth." The 1881 plan called for the removal of rock hindering navigation, the contraction of the river to compel the river to scour its bed (now known as regulating works), and to be aided by dredging, if necessary. The 1881 plan also provided for bank protection improvements (now known as revetment) wherever the river is causing any serious caving of its banks. (Letter from the Secretary of War, dated November 25, 1881, 47th Congress, 1st Session, Ex. Doc. No. 10). The Project's current dimensions of the navigation channel were established in the Rivers and Harbors Acts dated January 21, 1927 and July 3, 1930. The Rivers and Harbors Act dated January 21, 1927 modified the Project pursuant to the Chief of Engineers recommendations, which further detailed the purpose of the Project to construct the channel through regulating works and augment this by dredging, stating that dredging should be reduced to a minimum. The Project was also later modified to provide for the Chain of Rocks Canal and Lock 27 in the Rivers and Harbors Acts dated March 2, 1945 to address the rock formation hindering navigation in this area, and the rock filled low water dam at the Chain of Rocks was authorized in the Rivers and Harbors Act dated July 3, 1958 to assure adequate depth over the lower gate sills at Locks and Dam 26.

To the extent possible under existing authorities, environmental laws, regulations, and policies, the District considers the environmental consequences of its activities as it constructs and operates the Project and acts accordingly. An important component of each activity is the use of scientific, economic, and social knowledge to understand the environmental context and effects of District actions in a collaborative manner, employing an open, transparent process that respects the views of Federal and State stakeholders, individuals, and groups interested in District activities.

Frequent dredging has been required in the area of the proposed Regulating Works, Mosenthein/Ivory Landing Phase 5 construction work area (Mosenthein/Ivory Landing Phase 5 work area; see a detailed discussion of this in Section 3, Affected Environment). Therefore, after analysis of this area, the District concluded that construction of the Mosenthein/Ivory Landing Phase 5 work area is reasonable and necessary to address the repetitive channel maintenance dredging in order to provide a sustainable, less costly navigation channel in this area. The District has concluded through analysis and modeling that construction of river training structures would provide a sustainable alternative to repetitive maintenance dredging. Contract award for this work is expected in September 2015. At the earliest, Notice to Proceed for construction would follow within one month of contract award, giving the contractor one year to complete construction from the date of the Notice to Proceed.

The planning of specific construction areas, including the Mosenthein/Ivory Landing Phase 5 work area, required extensive coordination with resource agency partners and the navigation industry. The U.S. Fish and Wildlife Service, Missouri Department of Conservation, Illinois Department of Natural Resources, and multiple navigation industry groups were included in the planning of the Mosenthein/Ivory Landing Phase 5 work and provided comments related to navigation industry concerns and environmental resource issues that are documented in the District's Technical Report M68, *The Mouth of the Meramec River HSR Model, Mississippi River, River Miles 165.00 – 156.00, Hydraulic Sediment Response Model Investigation* (USACE 2014).

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 resources, ecosystem and human environment to warrant the preparation of a Supplemental EIS (SEIS).

The significant new circumstances and information on the potential impacts of the Regulating Works Project relevant to this EA include the following:

- New federally threatened and endangered species have been listed since preparation of the 1976 EIS. Information on threatened and endangered species and impacts on those species can be found in Section 3, Section 4, and Appendix B of this document.

- New information exists on the changes in average river planform width (the river's outline or morphology as defined by the tree line) in response to river training structure placement. Information on recent studies of planform width can be found in Section 3 of this document.
- New information exists on the impacts of river training structures and dredging on fish and macroinvertebrates. Information on fish and macroinvertebrates and projected impacts can be found in Sections 3 and 4 of this document.
- The District has implemented new programs to restore fish and wildlife habitat on the MMR. Information on the Biological Opinion Program and the Avoid and Minimize Program can be found in Section 4 of this document.
- New information exists on the effects of navigation on fish and wildlife resources. Information on navigation effects can be found in Appendix C, Cumulative Impacts Analysis.

The Mosenthein/Ivory Landing Phase 5 EA incorporates new information and circumstances relevant to the impacts of the action on the environment to the greatest extent possible. Should the analyses undertaken as part of the SEIS process reveal any new impacts on the resources, ecosystem, and 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 on the District's SEIS web site:

http://www.mvs.usace.army.mil/Missions/Navigation/SEIS.aspx

Figure 1. Work area location.

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 authorized depth and width of the navigation channel at the Mosenthein/Ivory Landing Phase 5 work area. 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 work area but continuing to maintain the existing river training structures. Dredging would continue as needed to address the shoaling issues in the work area to fulfill the Project's navigation purpose.

Alternative 2: Proposed Action. Phase 5 will consist of four bendway weirs on the right descending bank and three dikes on the left descending bank between RMs 160 and 162.5. (see Table 1 and Figures 2, 3 and 4 below).The primary purpose of the Phase 5 work is to reduce the amount of repetitive dredging required to maintain the authorized depth and width of the navigation channel in the work area. By constructing new regulating works structures in the work area, the energy of the flowing river would be focused to maintain the channel and thereby eliminate or reduce the amount of maintenance dredging. A secondary purpose of the work is to enhance or improve aquatic habitat diversity. Under the Proposed Action, the weirs would be used to redirect channel flows to reduce dredging. The dikes would serve this purpose also, but would also enhance aquatic habitat by directing some of the flow to the side channels and channel border areas.

Table 1. Work to be Completed by River Mile and Purpose of Work.

Location by mile	Work to be completed	Purpose
Weir 162.30R Weir 162.20R Weir 162.10R Weir 162.00R	Construct bendway weirs along the right descending bank.	Direct energy of the river toward the thalweg to reduce the need for dredging.
Dike 161.70L (Rootless) Dike 161.50L (Rootless) Dike 161.10L (Rootless)	Construct rootless dikes along the left descending bank.	The dikes will direct flow toward the repetitive dredging area in the main channel and will guide some of the flow toward the secondary channel and channel border area.

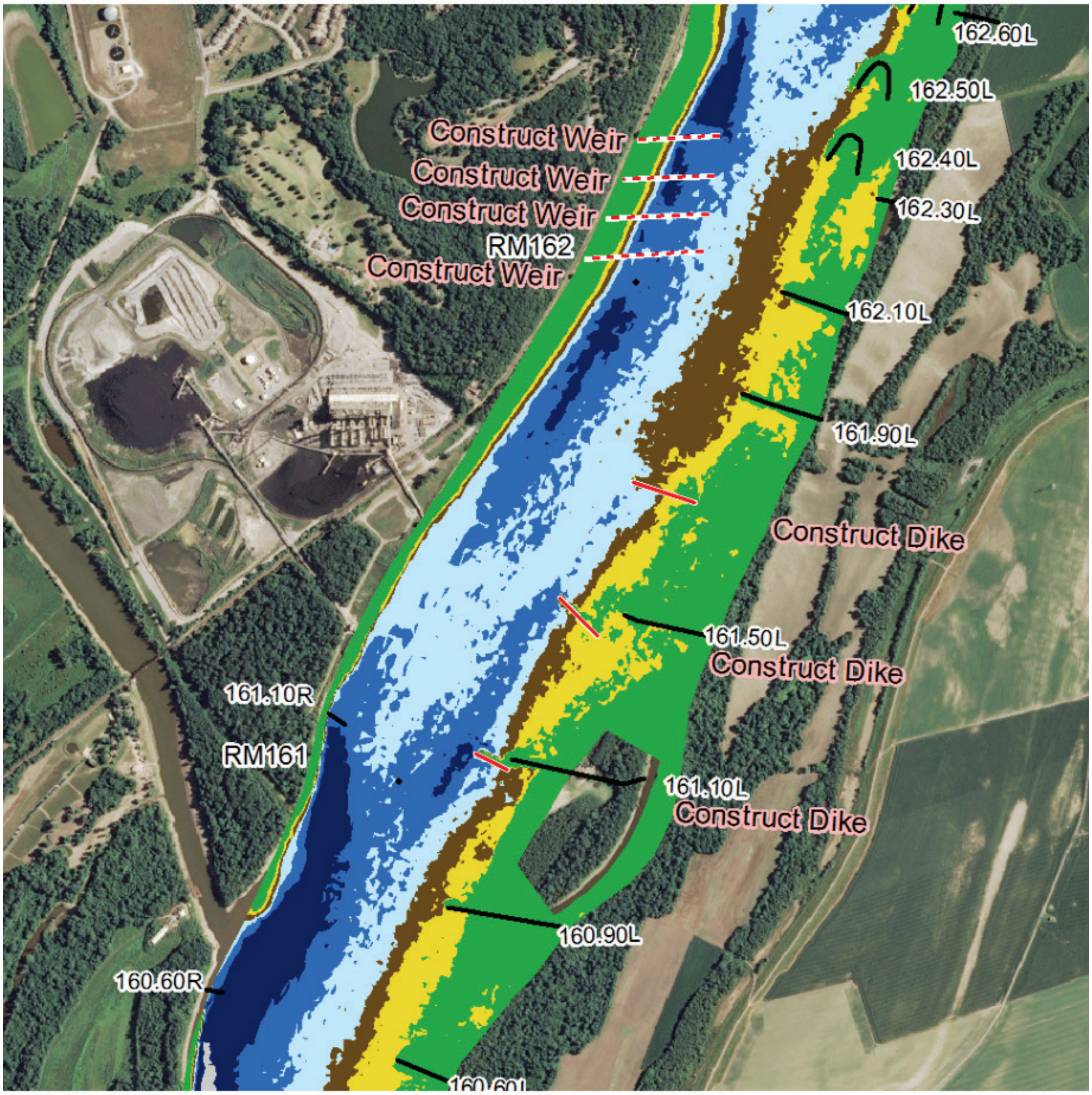

Figure 2. Locations of proposed weirs and dikes.

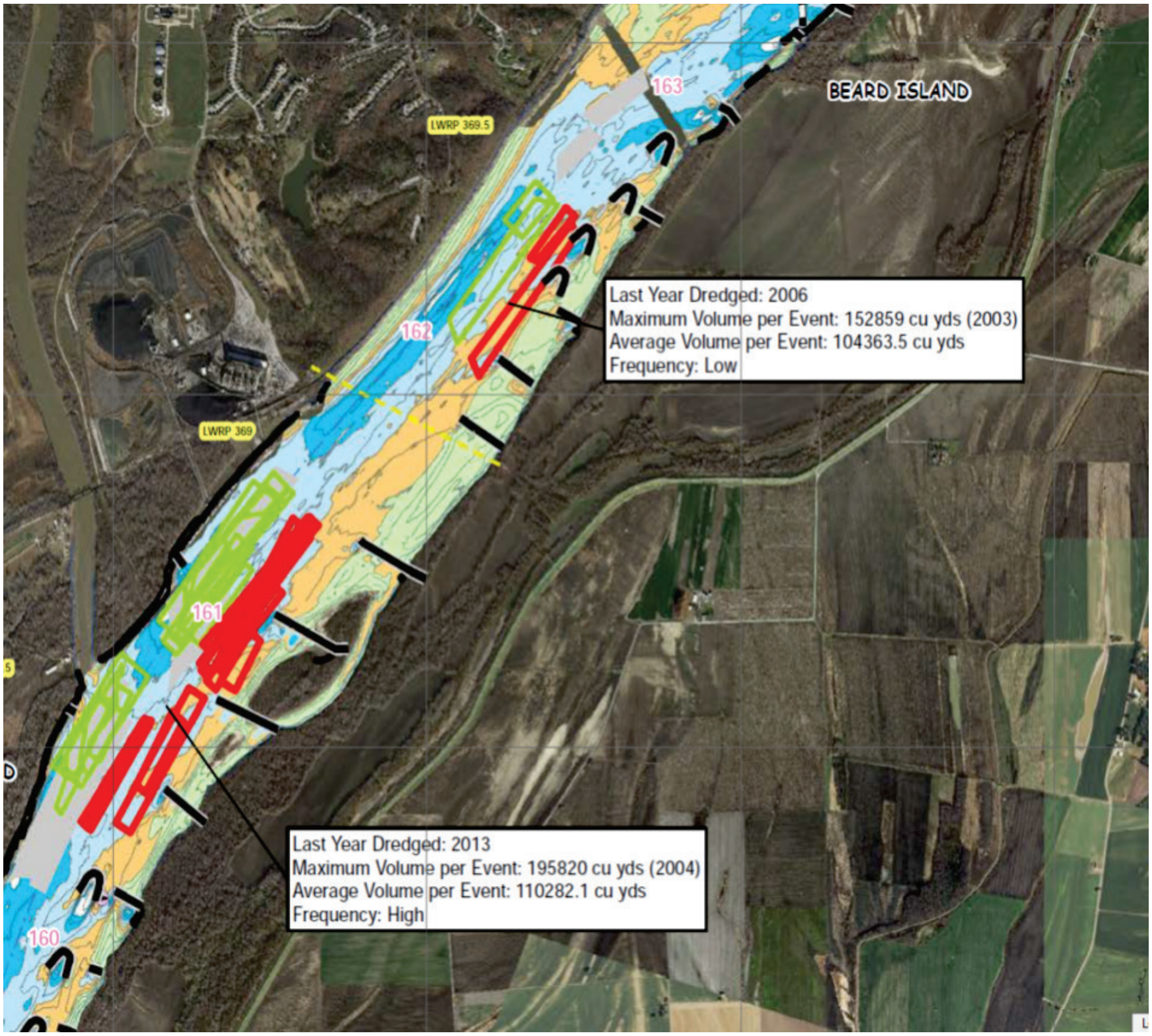

Figure 3. Dredging and Placement Sites Located in the Phase 5 Work Area.

Development of Alternatives - The District has concluded Alternatives 1and 2 are the only reasonable alternatives that meet the Project purpose and should be extensively evaluated. The District's alternative evaluation process considered only those alternatives that will obtain and maintain a safe and reliable 9-foot navigation channel in the work area to be consistent with the objectives and the authority of the Middle Mississippi River Regulating Works Project. The only reasonable, feasible, and authorized methods to keep the navigation channel open is through continued maintenance dredging or construction of regulating works to minimize the dredging required. Some of the other alternatives considered but deemed unreasonable include those discussed in the 1976 EIS. The 1976 EIS adequately addresses why some alternatives are not reasonable, such as ceasing all activity or building locks and dams. Maintenance of the navigation channel in this reach of the river requires frequent, costly dredging. Therefore, pursuant to the Project's authority, the District began developing alternatives to include regulating works to minimize the dredging in this reach of the river, thereby providing a less costly and more reliable navigation channel.

For the Mosenthein-Ivory Phase 5 work area, the District developed alternatives using widely recognized and accepted river engineering guidance and practice, and then screened and analyzed different configurations of regulating works with the assistance of a Hydraulic Sediment Response model (HSR model). HSR models are small-scale physical sediment transport models used by the District to replicate the mechanics of river sediment transport. HSR models allow the District to develop multiple configurations of river training structures for addressing the specific objectives of the work area in question in a cost-effective and efficient manner. The process of alternatives development using HSR models starts with the District calibrating the model to replicate work area conditions. Various configurations of river training structures are then applied to the models to determine their effectiveness in addressing the needs of the work area. For the Mosenthein/Ivory Landing Phase 5 work area the District developed the Mouth of the Meramec HSR model study. The Mouth of the Meramec HSR model study analyzed 16 different configurations of river training structures to determine the best combinations for reducing the need for dredging in the lower Mosenthein/Ivory reach while minimizing environmental impacts and not impacting fleeting areas on the LDB or the Ameren MO water intake at 161.5 (R).

Alternative 16, Plate 39 of the study, was recommended as the most desirable alternative because of its observed ability to significantly reduce elevations observed in the repetitive dredging area between RM 162.00 and RM 160.00. This alternative also included rootless dike structures in an effort to provide split flow and more channel border habitat in the area. Rootless Dike 161.50 was placed at an angle in an attempt to divert a small amount of additional flow towards the small side channel located along the left descending bank. Flow visualization observed in the HSR model showed a slight increase in the amount of flow entering the side channel. It should be noted that throughout testing, no sediment movement was observed within the side channel; however, at the model's scale it may not have been observable. Overall, this alternative enhanced navigation safety for industry by providing a deeper navigation channel while maintaining and potentially creating additional channel border habitat within the work area. See Figure 4 for a qualitative side by side comparison of modeled existing conditions and the potential bathymetric results.

During the alternative evaluation process, the District worked closely with industry and natural resource agency partners to evaluate potential alternatives in this reach of the river, including the 16 configurations analyzed in the HSR model. Ameren representatives voiced concern about siltation at the Ameren intake structure in the area. The USFWS questioned why several alternatives that required less construction, but seemed to yield satisfactory navigation channel results, were not considered.

In order to determine the best alternative, certain criteria, based on the study purpose and goals, were used to evaluate each alternative. The first and most important consideration was that the alternative had to reduce or eliminate the amount of dredging necessary between RM 162.00 and RM 160.00. The second condition was that the design should incorporate measures intended to avoid and minimize negative impacts to the environment, so long as the primary goal of reducing the need for dredging was not compromised. Although there were a number of alternatives that showed improvements to the repetitive dredging locations while maintaining the navigation channel requirements, the selected alternative provided the highest likelihood of achieving this goal. Other alternatives showed a significant reduction in dredging, but were not chosen because they utilized structure sets that did not have features intended to avoid and minimize negative environmental impacts. Other alternatives would have been problematic for the Ameren facility located along the RDB. Ultimately, Alternative 16 was the only alternative that satisfied all evaluation criteria.

This process resulted in the Proposed Action, which reasonably met the Project purpose while creating the possibility of more channel border habitat. Based on this extensive evaluation of alternatives, the District determined that the Proposed Action was the only reasonable alternative to dredging at the current level and that more extensive analysis of any of the additional configurations of regulating works in the EA would be unnecessary. 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 Appendix D of the HSR report for minutes of the Meramec HSR coordination meeting.

Ultimately, construction of four weirs and three dikes between RMs 162.5 and 160 was determined to provide the best results for the work area. Detailed information on the Alternatives considered can be found in the on-line Mouth of the Meramec HSR model study report:

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

Pursuant to 40 CFR 1502.21 and CEQ Guidelines, the Mouth of the Meramec HSR model study report is fully incorporated by reference into this EA for the purpose of reducing the size of this EA and not duplicating applicable analyses.

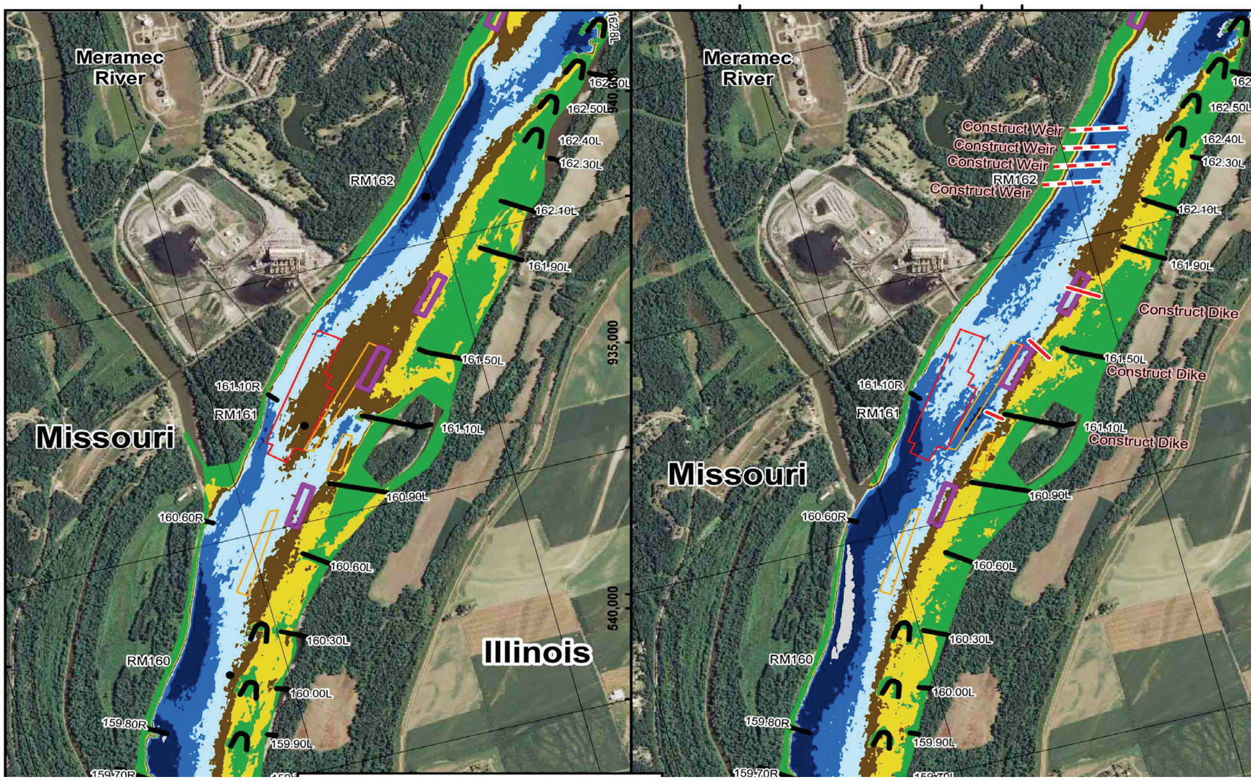

Figure 4. HSR model images showing how the structures will reduce river deposition.

Summary of Environmental Consequences - The impacts of each Alternative on the human environment are covered in detail in Section 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 Alternative and the Proposed Action.

	No Action Alternative	**Proposed Action**
Achievement of Project objectives	Does not reduce the need for repetitive maintenance dredging in the area, and, therefore, does not meet the Project objectives.	Is expected to reduce the amount of repetitive maintenance dredging in the area, thereby reducing federal expenditures and meeting Project objectives.
Impacts on Stages	No impacts anticipated.	No impacts anticipated at average and higher flows. Trend toward slightly lower stages at low flows 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	Minimal air quality impacts; below de minimis levels.	Minimal air quality impacts; below de minimis levels.
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.
Impacts on Threatened and Endangered Species	May affect but not likely to adversely affect threatened and endangered species.	No significant impacts to threatened and endangered species anticipated.
Impacts on Navigation	Continued requirement for repetitive maintenance dredging and associated potential for barge groundings.	Reduction in the amount and frequency of repetitive maintenance dredging in the area; reduction in barge grounding rates
Impacts on Historic and Cultural Resources	No known historic resources would be affected. Impacts to unknown historic and cultural resources unlikely.	No known historic resources would be affected. Impacts to unknown historic and cultural resources unlikely.

3. Affected Environment

This section presents details on the historic and existing conditions of resources within the work 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 (1866 to present) 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 (see Figure 5 below). 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.

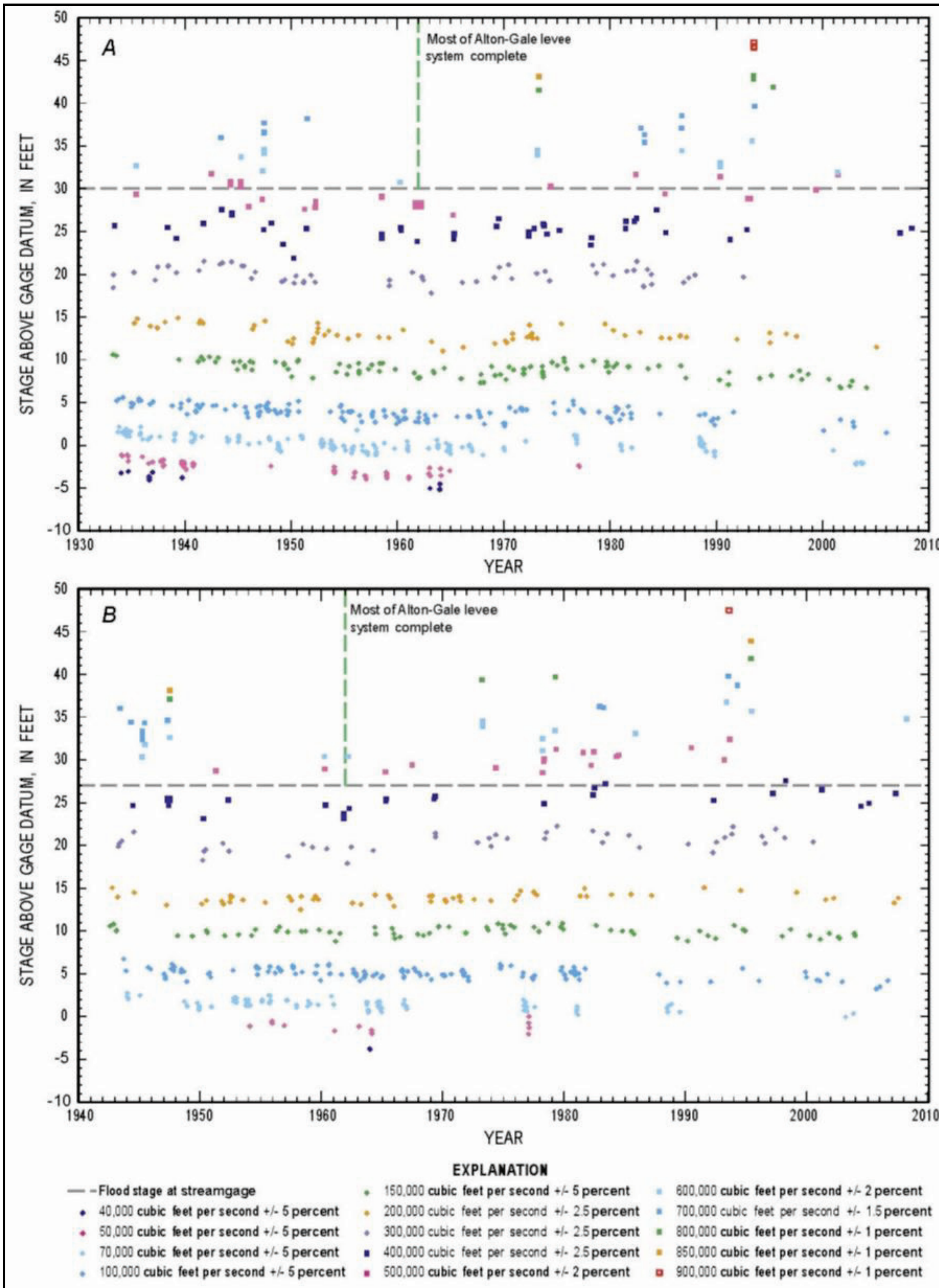

Figure 5. Stage for a given discharge range with time from measurements made at the streamgages at (A) St. Louis, Missouri, and (B) Chester, Illinois, on the Middle Mississippi River (from Huizinga 2009).

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 2014 303(d) list for Illinois, the Mississippi River in the vicinity of the work area was listed as impaired. The Mississippi River is on the 2014 303(d) list for Missouri between St Louis, MO, and Ste Genevieve, MO.

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 (NAAQS) 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 or as being maintenance areas. Maintenance areas are those areas that have been redesignated as in attainment from a previous nonattainment status. A maintenance plan establishes measures to control emissions to ensure the air quality standard is maintained in these areas. On the Missouri side, the Mosenthein/Ivory Landing Phase 5 work area (St. Louis Co.) is designated as a moderate nonattainment area for 8-hour ozone (1997 standard), a marginal nonattainment area for 8-hour ozone (2008 standard), and a moderate nonattainment area for particulate matter-2.5 (1997 standard) (USEPA 2015). On the Illinois side, the work area (Monroe Co.) is designated as a maintenance area for 8-hour ozone (1997 standard), a marginal nonattainment area for 8-hour ozone (2008 standard), and a moderate nonattainment area for particulate matter2.5 (1997 standard) (USEPA 2015).

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 (e.g., 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 Middle Mississippi River 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 6 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, structure elevation, and bank protection. As detailed in the HSR model report, the river planform in the work area followed a trend similar to that of the entire MMR, going through a period of expansion in the early 1800s, followed by a period of contraction in the late 1800s and early 1900s, then relative stability since the 1950s.

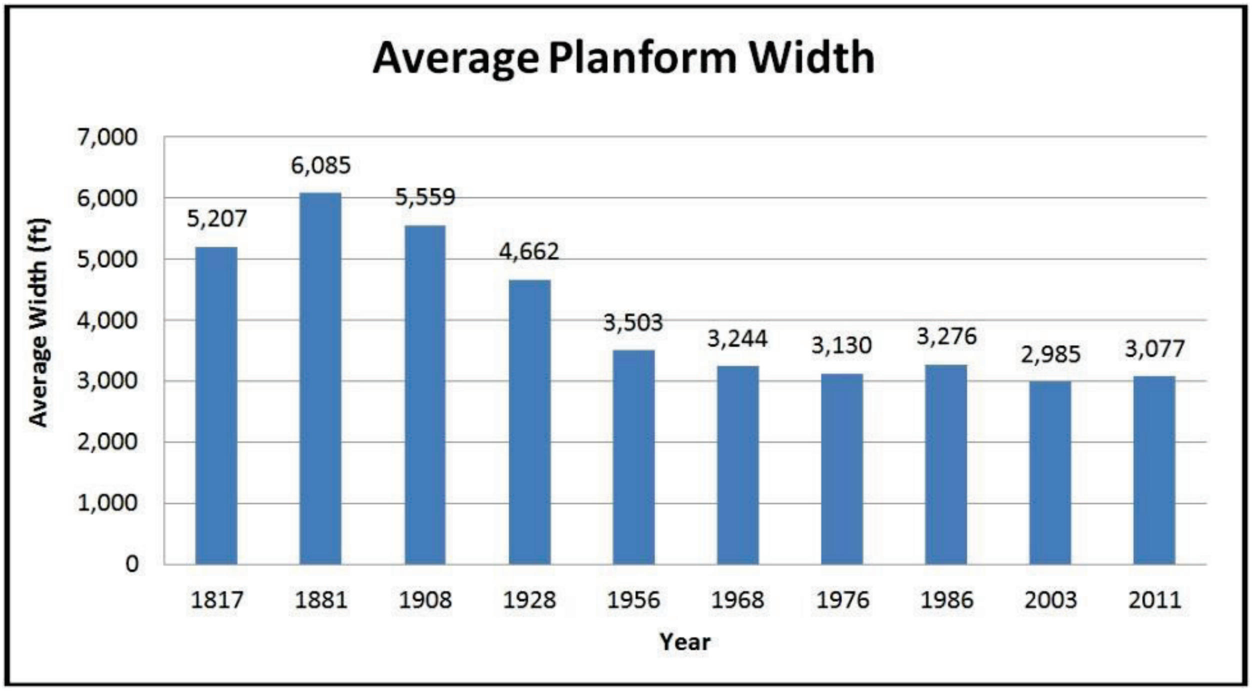

Figure 6. Average planform width of the MMR from 1817 to 2011.

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 (depth) 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 work area consists of a variety of habitat types, including main channel, main-channel border unstructured, main-channel border wing-dike, and side-channel. The work area likely fulfills the habitat requirements for the major habitat guilds of large river fishes: fluvial specialists, fluvial dependents, and macrohabitat generalists. Fluvial specialists are species found almost exclusively in lotic, or flowing water, systems, and require flowing water for all of their life cycles (Kinsolving and Bain 1993). Fluvial dependent species will occur in both lentic, or non-flowing, and lotic habitats, but require flowing water during one or more life stages (e.g., reproduction; Galat et al. 2005b). Macrohabitat generalist species are also commonly found in both lentic and lotic habitats, but do not require flowing water for any particular life stage (Kinsolving and Bain 1993). Stretches of unstructured main-channel and main channel border areas provide the preferred habitat of MMR fluvial specialists and fluvial dependents: moderate depths of flowing water over a sandy substrate. Main channel border wing dike areas produce pockets of lentic habitat in the form of flow refugia and plunge pools, providing habitat often used by macrohabitat generalists. The side channel in the area provides arguably the most important habitat type in the MMR, as it creates lateral connectivity and is likely used as a surrogate for floodplain and backwater habitat by many species in the MMR. Data collected by the Upper Mississippi River Restoration - Environmental Management Program Long Term Resource Monitoring Program (LTRMP) in the MMR demonstrates that most macrohabitat generalists are collected in greater abundance from side channels compared to other macrohabitat types (Simmons 2015), presumably due to the shallow, low-velocity habitat they provide at certain river stages.

LTRMP fish community monitoring conducted in the MMR from river miles 80 to 29 from 2000 to 2012 collected 108 species of fish. The most commonly encountered native and non-native species can be found in Table 3 below. Due to the fact that the habitat in the work area is similar to the MMR habitats sampled by the LTRMP, it is presumed that species composition in the work area would be similar as well.

Table 3. Common species of fish collected in the MMR by LTRMP from 2000 to 2012.

Species	Percent of Total Catch by Number	Habitat Use Guild*
Native Species		
Gizzard Shad (*Dorosoma cepedianum*)	16.8%	Macrohabitat Generalist
Channel Catfish (*Ictalurus punctatus*)	14.6%	Macrohabitat Generalist
Freshwater Drum (*Aplodinotus grunniens*)	7.0%	Macrohabitat Generalist
Emerald Shiner (*Notropis atherinoides*)	6.9%	Macrohabitat Generalist
Smallmouth Buffalo (*Ictiobus bubalus*)	4.7%	Macrohabitat Generalist
Channel Shiner (*N. wickliffi*)	4.5%	Fluvial Specialist
Red Shiner (*Cyprinella lutrensis*)	3.8%	Macrohabitat Generalist
Shortnose Gar (*Lepisosteus platostomus*)	3.7%	Macrohabitat Generalist
River Carpsucker (*Carpiodes carpio*)	3.0%	Macrohabitat Generalist
White Bass (*Morone chrysops*)	2.9%	Fluvial Dependent
Bluegill (*Lepomis macrochirus*)	2.4%	Macrohabitat Generalist
Blue Catfish (*I. furcatus*)	1.8%	Fluvial Specialist
Non-Native Species		
Common Carp (*Cyprinus carpio*)	9.3%	Macrohabitat Generalist
Silver Carp (*Hypophthalmichthys molitrix*)	1.0%	Fluvial Dependent
Bighead Carp (*H. nobilis*)	0.3%	Fluvial Dependent
Grass Carp (*Ctenopharyngodon idella*)	0.2%	Fluvial Dependent

* Habitat use guild classification based on Galat et al. (2005b).

The Middle Mississippi River 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.

Threatened and Endangered Species – Based on coordination with the U.S. Fish and Wildlife Service, 16 federally threatened or endangered species could potentially be found in the area. The 16 species, federal protection status, and habitat description are shown in Table 4. No critical habitat is located in the work area.

Table 4. Federally listed threatened and endangered species potentially occurring in the work area.

Species	Federal Status	Habitat
Gray bat (*Myotis grisescens*)	Endangered	Caves
Indiana bat (*Myotis sodalis*)	Endangered	Hibernacula: Caves and mines; Maternity and foraging habitat: small stream corridors with well developed riparian woods; upland forests
Northern long-eared bat (*Myotis septentrionalis*)	Proposed Endangered	Hibernacula: Caves and mines; Maternity and foraging habitat: the understory of forested hillsides and ridges, small stream corridors with well developed riparian woods; upland forests.
Pallid sturgeon (*Scaphirhynchus albus*)	Endangered	Mississippi and Missouri Rivers.
Least tern (*Sterna antillarum*)	Endangered	Bare alluvial and dredged material islands.
Decurrent false aster (*Boltonia decurrens*)	Threatened	Disturbed alluvial soils.
Illinois cave amphipod *(Gammarus acherondytes)*	Endangered	Cave streams in Illinois sinkhole plain.
Mead's milkweed (*Asclepias meadii*)	Threatened	Moderately wet (mesic) to moderately dry (dry mesic) upland tallgrass prairie or glade/barren habitat.
Running buffalo clover (*Trifolium stoloniferum*)	Endangered	This species may be found in partially shaded woodlots, mowed areas and along streams and trails.
Pink mucket (*Lampsilis abrupta*)	Endangered	This species is found in mud and sand and in shallow riffles and shoals swept free of silt in major rivers and tributaries.
Scaleshell mussel (*Leptodea leptodon*)	Endangered	Lives in medium-sized and large rivers with stable channels and good water quality.
Sheepnose mussel (*Plethobasus cyphyus*)	Endangered	Rivers and streams.

Species	Federal Status	Habitat
Spectaclecase mussel (*Cumberlandia monodonta*)	Endangered	Spectaclecase mussels are found in large rivers where they live in areas sheltered from the main force of the river current.
Piping plover (*Charadrius melodus*) Northern Great Plains Breeding Population	Threatened	Riverine sandbars
Rufa Red knot (*Calidris canutus rufa*)	Threatened	Shorebird that migrates through Missouri – irregularly observed feeding on mudflats, sandbars, shallowly flooded areas and pond margins along the Missouri and Mississippi Rivers from May 1 through September 30.
Snuffbox (*Epioblasma triquetra*)	Endangered	Small to medium-sized creeks with a swift current.

Socioeconomic Resources

Navigation - The Middle Mississippi River is a critically important navigation corridor that provides for movement of a wide variety of commodities of local, national, and international importance. The St. Louis Harbor is the third busiest inland port in the nation. Approximately 106 million tons of cargo passed through the MMR in 2011 (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 is a common practice used on the Mississippi River to maintain the river at the proper depth, width, and channel alignment for navigation. Just upstream of the confluence of the Meramec and Mississippi Rivers, repetitive channel maintenance dredging has routinely occurred. Figure 7 shows the annual amount of material removed from 1994 to 2014 and Figure 8 shows the associated cost for the same time period. In the last 5 years, approximately 600,000 cubic yards of material has been removed between RM 162.00 and RM 160.00 at a cost of approximately $1.7M.

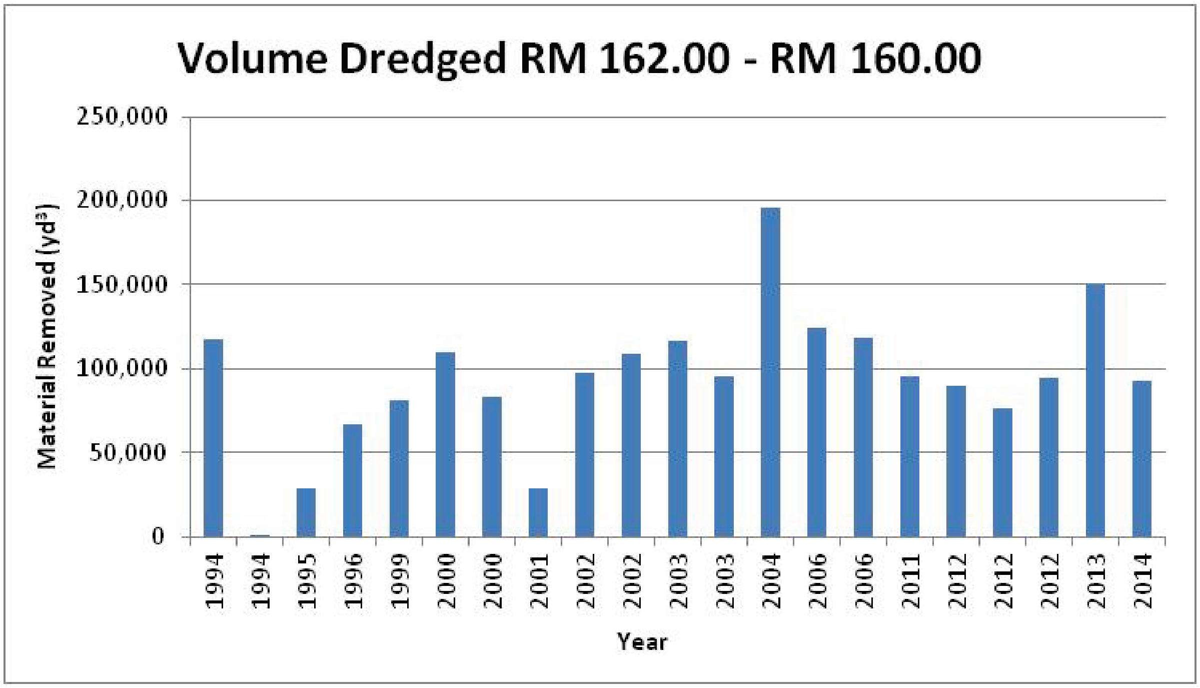

Figure 7. Volume of material dredged in work area from 1994 to 2014.

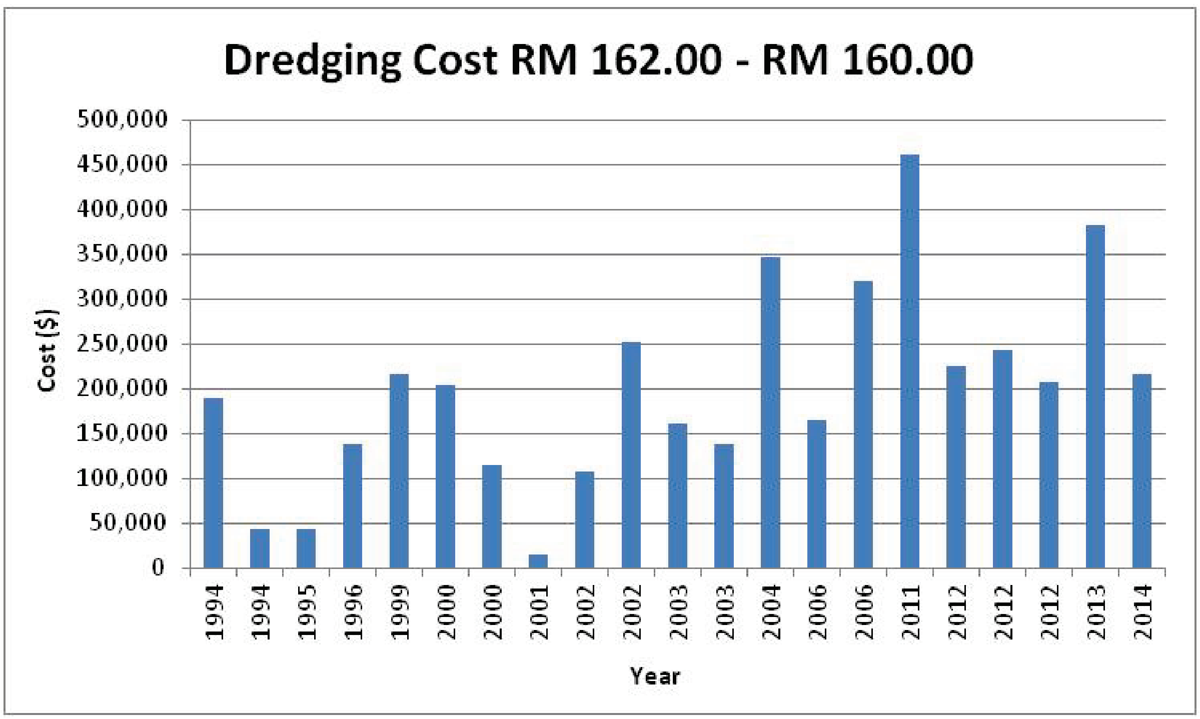

Figure 8. Cost of dredging in work area from 1994 to 2014.

Historic and Cultural Resources

Compared to some other segments of the Mississippi River, the course of the Mosenthein Reach has remained relatively consistent for the last 150 years. As with much of the river in the American Bottom, there has been narrowing with the accretion of land on the Illinois side. By

1908, however, the Illinois bankline in the immediate work area stabilized near its current position and the only major change to the Missouri bank was the accretion of land below the Missouri bluffs at the mouth of the Meramec River (see Appendix F).

During the summer of 1988 when the Mississippi River was at one of its lowest levels 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 wreck sites to the work area were over two miles away, both upstream and downstream.

Most of the proposed structures are next to dredged channels, which probably resulted in channel slump and sediment reworking in the locations. The Mosenthein 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. The USACE has been conducting such activities to deepen the navigation channel of the Middle Mississippi since 1896 (Manders and Rentfro 2011:61).

The river bed in the work area is surveyed every one to two years, with the latest survey having been completed on May 14, 2013. The single-beam survey was conducted with range lines spacing of approximately 200 feet. No topographic anomalies suggesting wrecks were visible on the resulting bathymetric map.

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 area, but continuing to maintain the existing river training structures. Dredging under the No Action Alternative would continue as needed to address the shoaling issues in the area. The Proposed Action consists of constructing three dikes (all three of which could be considered rootless) and four bendway weirs between RMs 160 and 162 on the left descending bank.

Physical Resources

Stages

Impacts of the No Action Alternative on Stages – Stages in the work area vicinity and the Middle Mississippi River 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 work area vicinity 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 1930s. 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. Based on all of the analyses of the Regulating Works program on stage impacts, USACE concludes that flood risks are not increased.

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 minor local effect on water surface elevations at lower flows, any cumulative impacts are being minimized through the use of innovative river training structures and through other District programs, which have currently seen success in restoring and preserving side channels affected by river training structures *(see Appendix C, Cumulative Impacts Analysis).* On a local scale, due to the fact that innovative river training structures were used in the design of this work area to direct flow to the adjacent side channel, and due to the fact that the HSR model showed a slight increase in the amount of flow entering the side channel, we do not anticipate any negative impacts from the work on side channel habitat. Bathymetric information collected in the adjacent side channel since the 1950s shows steady improvement in average depths, increasing from 6.6 feet in 1956 to 18.8 feet in 2014. This trend is expected to continue with implementation of the Mosenthein/Ivory Landing Phase 5 work.

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 dike structures are designed to change the sedimentation patterns in the area and would, therefore, cause some minor temporary changes in the suspended sediment concentration in the immediate 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 work under sections 404 and 401 of the Clean Water Act. All permits necessary for completion of the work have been applied for and will be obtained prior to implementation.

Air Quality

Impacts of the No Action Alternative on Air Quality – Air quality in the vicinity of the work 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. An analysis was conducted to determine the conformity of the repetitive dredging to the State Implementation Plan (SIP) for the states of Missouri and Illinois. The MV Dredge Potter (2400 hp) is expected to be used about 45 days per year to perform this dredging in the work area's reach of the river (river miles 160.0-171.0), and this is a worst-case scenario based on historic dredging records (2000-2013). During operation, this maintenance dredging equipment would generate emissions including volatile organic compounds (VOCs), oxides of nitrogen (NOx), and particulate matter (PM). Based on use of this equipment, the quantitative assessment estimates annual emissions of 1.8 tons of VOCs, 60.8 tons of NOx, and 17.7 tons of PM. These estimates are below the de minimis levels set for the nonattainment areas, which are 50 tons per year of VOCs, 100 tons per year of NOx, and 100 tons per year of PM.

The worst-case scenario assessment also shows that maintenance dredging is not regionally significant as estimated emissions would not exceed 10% of the total emissions in the nonattainment area. In 2012, VOC emissions from all sources in Monroe County, Illinois, were 2,301 tons, NOx emissions from all sources were 2,124 tons, and PM10 and PM2.5 emissions from all sources were 754 and 349 tons, respectively (USEPA undated). In 2012, VOC emissions from all sources in St. Louis County, Missouri, were 32,362 tons, NOx emissions from all sources were 35,070 tons, and PM10 and PM2.5 emissions from all sources were 31,662 and 7,444 tons, respectively (USEPA undated).

Based on this worst-case scenario analysis, air quality impacts from maintenance dredging performed in the work area's reach of the river are minor.

Impacts of the Proposed Action on Air Quality – When a federal action is being undertaken in a nonattainment area, the federal agency responsible for the action is required to determine if its action conforms to the applicable State Implementation Plan (SIP). A SIP is a plan that provides for implementation, maintenance, and enforcement of the National Ambient Air Quality Standards (NAAQS) and includes emission limitations and control measures to attain and maintain the NAAQS. An analysis was conducted to determine the conformity of the Mosenthein/Ivory Landing Phase 5 work to the SIPs for the states of Missouri and Illinois.

Equipment needed to construct the proposed features is assumed to include two push boats (880 hp) and a dragline crane (300 hp). Assuming these features would not eliminate the need for maintenance dredging in the work area, the MV Dredge Potter (2400 hp) is assumed to be required as a worst-case scenario for all the time of the No Action alternative. During operation, this equipment would generate emissions including volatile organic compounds (VOCs), oxides of nitrogen (NOx), and particulate matter (PM). Based on use of this equipment, the quantitative assessment estimates annual emissions of 2.2 tons of VOCs, 73.3 tons of NOx, and 20.6 tons of PM. These estimates are below the de minimis levels set for the nonattainment areas, which are 50 tons per year of VOCs, 100 tons per year of NOx, and 100 tons per year of PM.

The worst-case scenario assessment also shows that maintenance dredging plus construction is not regionally significant as estimated emissions would not exceed 10% of the total emissions in the nonattainment area. In 2012, VOC emissions from all sources in Monroe County, Illinois, were 2,301 tons, NOx emissions from all sources were 2,124 tons, and PM10 and PM2.5 emissions from all sources were 754 and 349 tons, respectively (USEPA undated). In 2012, VOC emissions from all sources in St. Louis County, Missouri, were 32,362 tons, NOx emissions from all sources were 35,070 tons, and PM10 and PM2.5 emissions from all sources were 31,662 and 7,444 tons, respectively (USEPA undated).

Based on this worst-case scenario analysis, air quality impacts from the proposed construction activities in combination with maintenance dredging performed in this work area's reach of the river would be minor.

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. 2005a). 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 (Badgett 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. A total of approximately 1,000,000 cubic yards of material was dredged during the project, and fish entrainment monitoring was conducted during approximately 15% of the operation. No pallid sturgeon were captured during the study. 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 a 1974 study (Solomon 1974) benthic organisms collected from dredged, disposal, and river border locations varied in abundance and diversity. Lowest abundance and diversity were observed at previously dredged sites; greater abundance and diversity at existing disposal sites; and highest values were observed at river border areas. The association of benthic organisms with median grain size of sediment samples was not well defined; however, it was apparent that greater numbers of organisms were associated with the smaller sediment particles (those corresponding to silt or clay and to the lower size range of fine sand). The sediment in the disposal and river border areas ranges from silt and/or clay to fine- and medium-sized sand. These finer grained substrate materials provide a more favorable habitat for benthic organisms. The majority of the dredging and dredge placement in the MMR takes place within repetitive dredging areas and placement areas that are located in the main channel, where fewer benthic organisms are found; therefore, dredging impacts to benthic organisms would likely be limited.

In summary, the amount of dredging going forward would remain similar to what has been experienced recently. Dredging and disposal 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 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 around 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. In addition, innovative structures such as the proposed rootless dikes are intended to provide bathymetric diversity, flow refuge, and split flow conditions that differ from traditional wing dikes. Based on the model studies conducted for the work area and District experience with similar river training structures, the proposed dikes are expected to reduce the elevation in the repetitive dredging area. In addition the rootless dikes and angled dike would help to improve channel border habitat by encouraging flow toward the side channel or channel border on the left descending bank. Connectivity to the side channel is anticipated to be maintained and the shallow, low-velocity habitat it provides will still be available to the fish community. Also, lotic habitat near the channel border will not be reduced, and pockets of lentic habitat will likely form behind the rootless dikes. Because innovative river training structures will be used in the work area, the habitat requirements of fluvial specialist, fluvial dependent, and macrohabitat generalist fish guilds will be maintained.

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 Middle Mississippi River 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.

Limited sampling conducted by the St. Louis District at an offset dike field in the MMR at RM 60.0 to 57.5 (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 and habitat diversity associated with chevron dikes as compared to pre-construction conditions and open water control sites.

In summary, the proposed rootless dikes are not expected to result in a loss of aquatic habitat due to sedimentation and conversion to terrestrial habitat. These structures are expected to increase bathymetric, flow, and sediment diversity in the immediate vicinity of the structures. Fish response to these changes in habitat is difficult to predict quantitatively, but, based on prior studies, the habitat requirements of the fish community will continue to be met in the project area..

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 Middle Mississippi River between Cairo, Illinois, and Cape Girardeau, Missouri (RM 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 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 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-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 four bendway weirs in the work area is expected to improve fluvial specialist and fluvial dependent fish habitat and macroinvertebrate habitat in the outside bend by providing substrate diversity, flow refuge, and increased surface area for macroinvertebrate colonization. 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 (including the MMR) and addressed listed species as projected 50 years into the future (USFWS 2000). The consultation did not include individual, site specific effects or new construction. It was agreed that site specific 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 Mosenthein/Ivory Landing Phase 5 work required Tier II consultation. Accordingly, the District prepared a Tier II Biological Assessment to determine the potential impacts of the work on federally threatened and endangered species (see Appendix B).

The Mosenthein-Ivory Landing Phase 5 Biological Assessment concluded that although adverse impacts to pallid sturgeon and the least tern 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, pallid sturgeon and the interior least tern may still be adversely affected. However, the adverse effects of the work on the pallid sturgeon and 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.

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 work area at this time. If any nest trees are identified in the work area, the National Bald Eagle Management Guidelines will be implemented to minimize potential 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, repetitive maintenance dredging activities would be expected to continue at a rate similar to recent history. In the last 5 years, approximately 600,000 cubic yards of material has been removed between RM 162.00 and RM 160.00 at a cost of approximately $1.7M.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 repetitive maintenance dredging necessary in the area. Extensive coordination with navigation industry partners was conducted and Ameren's concerns with impacts to their intake facility at RM 161.5 (R) were addressed. Accordingly, impacts to fleeting areas as well as other navigation concerns have been avoided. The rootless dike at RM 161.7 will be located in a designated fleeting area, but it is no longer in use. The cost of the Proposed Action is not expected to exceed $3,500,000.

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 area. Any undocumented historic and cultural resources that may have existed in the 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 work on the dikes and weirs 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 previous disturbance of the riverbed, and the lack of any survey evidence for extant wrecks, it is our 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 F. 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 to this date no objections to the project were raised. A copy of the consultation letter is included in Appendix F.

Climate Change. To date, no official guidance applicable to the Middle Mississippi River Regulating Works Project has been established for federal agencies in determining impacts of proposed actions on climate change or the impacts of climate change on proposed actions. Nonetheless, a general assessment of climate trends and the most likely future climate conditions can assist decision makers in characterizing the potential impacts of their actions on climate change and the potential impacts of climate change on water resources and the future efficacy of infrastructure.

As part of the requirements of the Global Change Research Act enacted in 1990, the United States Global Change Research Program periodically conducts National Climate Assessments. National Climate Assessments are intended to evaluate, integrate, and assess the most current climate change information available and make it available to the public. National Climate Assessments were prepared in 2000 and 2009 and the third report was published in 2014 (Mellilo et al. 2014). The information below (Kunkel et al. 2013a; Kunkel et al. 2013b) comes from the technical reports prepared in support of the third National Climate Assessment and represents the most up-to-date information available on climate trends and forecasts for the area.

For the National Climate Assessment analysis, the Midwest was defined as Minnesota, Wisconsin, Michigan, Iowa, Illinois, Indiana, Ohio, and Missouri. Despite a large degree of interannual variability, analyses of recent trends for annual precipitation totals and extreme precipitation events in the Midwest show upward trends (Kunkel et al. 2013a; Karl et al. 2009). Predictions of future precipitation characteristics for the Midwest are characterized by a high degree of variability and uncertainty (Winkler et al. 2012; Kunkel et al. 2013a), but the following conclusions about simulated future precipitation in the Midwest were drawn (Kunkel et al. 2013a):

- *The greatest simulated increases in average annual precipitation are seen in the far north, while a decrease is indicated in the southwestern corner of the region. Seasonal changes are generally upward in winter, spring, and fall and downward in summer in the south. However, the range of model-simulated precipitation changes is considerably larger than the multi-model mean change. Thus, there is great uncertainty associated with future precipitation changes in these scenarios.*

- *Simulated changes in the number of days with precipitation exceeding 1 inch are upward for the entire Midwest region, with increases of up to 60% (for the A2 scenario at mid-century). The largest changes are seen in the states bordering Canada. The increases are statistically significant generally in the north, but not in the south.*

- *Statistically significant decreases in the number of consecutive days with less than 0.1 inches of precipitation are simulated for the north (for the A2 scenario at mid-century). Elsewhere changes are not statistically significant.*

- *Many of the modeled values of decadal precipitation change are not statistically significant, with respect to 2001-2010, out to 2091-2099.*

Precipitation trends for the Great Plains watershed are also important considerations for the Middle Mississippi River given the contribution of the Missouri River to Middle Mississippi River flows. For the National Climate Assessment analysis, the Great Plains was defined as Montana, North Dakota, South Dakota, Wyoming, Nebraska, Kansas, Oklahoma, and Texas (Kunkel et al. 2013b). The following general conclusions about simulated future precipitation in the Great Plains were drawn (Kunkel et al. 2013b):

- *Southern regions show the largest simulated decreases in average annual precipitation, while northern areas show increases. NARCCAP models show increases across most of the region in all seasons except summer. For the most part, these changes are either not statistically significant or the models do not agree on the sign of the change. An exception is the modeled changes in the far northern and far southern portions of the region for 2070-2099 under the high (A2) emissions scenario where the models simulate statistically significant increases and decreases, respectively. For most time periods and locations, the range of model-simulated precipitation changes is considerably larger than the multi-model mean change. Thus, there is great uncertainty associated with future precipitation changes in these scenarios.*

- *Nearly the entire region is simulated to see increases (up to 27%) in the annual number of days with precipitation exceeding 1 inch (for the A2 scenario at mid-century), with small areas in the far western portions of the region simulated to see slight decreases (up to 23%). However, these changes are mostly not statistically significant.*

- *Consecutive days with little or no precipitation (less than 0.1 inches) are simulated to increase in the south by 3-13 days per year and decrease in parts of the north by up to 8 days per year (for the A2 scenario at mid-century). The decreases in Texas and Oklahoma are mostly statistically significant.*

- *Many of the modeled values of decadal precipitation change are not statistically significant, with respect to 2001-2010, out to 2091-2099.*

Given the high degree of variability and uncertainty in weather patterns in general and in predictions of future weather patterns in particular, quantifying future Project impacts is inexact. However, if the assumption is made that changes in future precipitation in the Middle Mississippi River watershed are going to be characterized by increased average annual precipitation, more frequent extreme rainfall events, and consequently more frequent and greater flood events, then the basic functionality of river training structures and their ability to change sedimentation patterns should not be affected going forward. Also, given that the District has concluded that river training structures do not increase flood heights (see Section 4, Environmental Consequences and Appendix A), river training structures would not contribute any increase to potential future flood events. Nonetheless, climate change could impact navigation by changing sedimentation patterns and associated impediments to navigation, increasing the need for dredging, and decreasing the dependability of the navigation channel due to floods and droughts (Moser et al. 2008; Karl et al. 2009).

With respect to impacts on climate change, implementation of the Proposed Action would result in some minor greenhouse gas emissions due to equipment used for construction activities, rock transportation, etc. However, the Proposed Action would result in an overall decrease in greenhouse gas emissions due to the reduction in the amount of repetitive maintenance dredging required in the work area.

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 Mosenthein/Ivory Landing Phase 5 EA cumulative impact analysis generally followed the steps laid out by the handbook.

As detailed in Appendix C and summarized in Table 5 below, the cumulative impact analysis involved determining the incremental impact of the 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 work area to include impacts to the resources throughout the Middle Mississippi River. Clearly the human environment in the Middle Mississippi River has been, and will continue to be, impacted by a wide range of actions. The cumulative impact analysis evaluates the same resources (Physical Resources [River Stages, Water Quality, and Air Quality]; Biological Resources [Fish and Wildlife: Dike Effects, Threatened & Endangered Species, and Climate Change]; Socioeconomic Resources [Navigation]; and Historic & Cultural Resources) that were evaluated in the Environmental Consequences section. In addition, the cumulative impacts for the No Action Alternative and Action Alternative were evaluated for navigation effects and side channel impacts.

The Regulating Works Project, in combination with the other actions 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 includes involving partner agencies throughout the planning process, avoiding and minimizing environmental impacts, and utilizing innovative river training structure configurations to provide fish habitat while still providing benefits to the navigation system. Although our understanding of the actions that bear upon the resources of the Middle Mississippi River continues to evolve, equilibrium in habitat conditions appears to have been reached. Accordingly, only minimal impacts to the resources, ecosystem and human environment are anticipated for the Mosenthein-Ivory Phase 5 work area.

Table 5. 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. Non-attainment status in work area.	Continued population growth and development result in increased potential for air quality impacts. Continued regulation enforcement and societal recognition. Continued non-attainment status in work area.	Continued population growth and development result in increased potential for air quality impacts. Continued regulation enforcement and societal recognition. Possible achievement of attainment status through implementation of State Implementation Plans.	Minimal air quality impacts; below de minimis levels	Minimal air quality impacts; below de minimis levels

Table 5. (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 above Chain of Rocks; in MMR, loss of floodplain habitat due to levees, agriculture, urbanization; loss of natural river habitat – loss of dynamic habitat due to river channel stabilization with dikes/ revetment; loss of side channel habitat; dredging impacts; navigation impacts; USACE, other federal, state, and private habitat restoration and land mgmt programs 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 above Chain of Rocks and existing dikes/revetment; continued implementation of Regulating Works Project; 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; navigation impacts; native species continue to be impacted by exotic species; continued implementation of Biological Opinion Program and Avoid and Minimize Program; restoration/maintenance of side channel habitat	Continued maintenance of habitat conditions due to maintenance of lock and dam system above Chain of Rocks and maintenance of existing dikes/revetment; dredging impacts; navigation impacts; continued implementation of Regulating Works Project; 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; restoration/maintenance of side channel habitat	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; no significant impacts to threatened and endangered species anticipated

Table 5. (cont.)

Resource	Past Actions	Present Actions	Future Actions	No Action Alternative	Proposed Action
Navigation	1927 River and Harbor Act authorized USACE to provide a 9-foot channel on MMR; USACE transformed free-flowing Mississippi River system into navigable waterway with 37 lock and dam complexes above Chain of Rocks, 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 above Chain of Rocks 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 above Chain of Rocks 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 repetitive maintenance dredging in the area; reduction in barge grounding rates
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	No known historic resources would be affected. Impacts to unknown historic and cultural resources unlikely.	No known historic resources would be affected. Impacts to unknown historic and cultural resources unlikely.

Mitigation

Mitigation measures are used to avoid, minimize, or compensate for adverse impacts to environmental resources. The Mosenthein/Ivory Landing Phase 5 work has avoided and minimized adverse impacts throughout the alternative development process. As a result of coordination with resource agencies, no adverse impacts have been identified that would require compensatory mitigation.

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	Full
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* Full compliance will be obtained prior to construction.

6. List of Preparers

Name	Role	Experience
Mike Rodgers	Project Manager	14 years, hydraulic engineering
Jasen Brown	Project Manager	14 years, hydraulic engineering
Eddie Brauer	Engineering Lead	14 years, hydraulic engineering
Kip Runyon	Environmental Lead	18 years, biology
Francis Walton	Environmental; Threatened and Endangered Species	15 years, environmental compliance
Tim George	Air Quality	25 years, ecology
Tom Keevin	Cumulative Impacts	35 years, aquatic ecology
Kevin Slattery	HTRW	17 years, environmental science
Mark Smith	Historic and Cultural Resources	22 years, archaeology
Danny McClendon	Regulatory	29 years, regulatory compliance and biology
Keli Broadstock	Legal Review	3 years USACE, 6 years private sector law

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FINDING OF NO SIGNIFICANT IMPACT (FONSI)

FINDING OF NO SIGNIFICANT IMPACT
MOSENTHEIN/IVORY LANDING PHASE 5 REGULATING WORKS
MIDDLE MISSISSIPPI RIVER MILES 160 – 162.5
MONROE COUNTY, IL
ST. LOUIS COUNTY, MO

I. In accordance with the National Environmental Policy Act, I have reviewed and evaluated the documents concerning the Regulating Works, Mosenthein/Ivory Landing Phase 5 construction, Monroe County, Illinois and St. Louis County, 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 possible consequences of these alternatives have been studied for physical, environmental, cultural, social and economic effects, and engineering feasibility. My evaluation of significant factors has contributed to my finding:

   a. The work would address repetitive dredging in the area. This would be accomplished by the construction of four bendway weirs and three dikes.

   b. No significant impacts to federally listed threatened or endangered species are anticipated.

   c. No significant impacts are anticipated to natural resources, including fish and wildlife resources. The proposed work would have no effect upon significant historic properties or archaeological resources. There would be no appreciable degradation to the physical environment (e.g., stages, air quality, and water quality) due to the work.

   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. Therefore, an Environmental Impact Statement will not be prepared prior to proceeding with the proposed Regulating Works, Mosenthein/Ivory Landing Phase 5 construction, Monroe County, Illinois and St. Louis County, Missouri.

2 Jun 2015
(Date)

ANTHONY P. MITCHELL
COL, EN
Commanding

ENVIRONMENTAL ASSESSMENT

WITH

FINDING OF NO SIGNIFICANT IMPACT

REGULATING WORKS PROJECT
MOSENTHEIN/IVORY LANDING PHASE 4
MIDDLE MISSISSIPPI RIVER MILES 160 – 162.5
MONROE COUNTY, IL
ST. LOUIS COUNTY, MO

JUNE 2015

APPENDICES

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

Summary of Research on the Effects of River Training Structures on Flood Levels

1. Introduction

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 1930s. This research includes numerical and physical models as well as analyses of historic gage data, velocity data, and cross sectional data. In addition to continued monitoring and analysis, the U.S. Army Corps of Engineers (Corps) has conducted a literature review of all available literature on the impact of river traning structures on flood levels. 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 impact flood levels.

2. Studies concluding no impact on flood levels

2.1 Historic Research

One of the early studies 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. When observed field data showed a major change in the stage for which a specific discharge was passing, the Corps and USGS initiated a study to determine the cause. This 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. Ressegieu (1952) concluded 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).

Monroe (1962) conducted a comprehensive analysis of all factors which are believed to have had some effect on the St. Louis rating curve including: accuracy of discharge measurements, man-made obstructions and hydrology and hydraulic changes. Monroe (1962) observed a spread in stage for equivalent discharge at flows with stages of about 35 and 40 ft on the St. Louis gage. The analysis concluded that the change in stage for higher flows was due to the construction and raising of levees between 1935 and 1951. In an analysis of river training structures, Monroe (1962) found that "the contraction by permeable dikes has had a negligible effect on the increase in flood heights." A number of natural factors were found to affect stages for equivalent discharge including: season (water temperature), rapidity of rise of the flood wave, amount of flow contribution by the upper Mississippi River and the amount of bed material carried by the Missouri River.

In a comprehensive study of hydrologic, hydraulic, geologic and morphologic factors which relate to the Mississippi River downstream of Alton, IL, 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 modeling that published discharges for historic floods, including 1844 and 1903, were overestimated by 33 and 23 percent, respectively. 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.

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 (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 (dikes are referred to as groynes in other parts of the world including the Netherlands) 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 (2.4 inches).

Other international research supports the conclusion that river training structures do not impact flood levels. An international technical working group made up of experts from around the world organized by PIANC, the World Association for Waterborne Transport Infrastructure, analyzed the impact of dikes on high discharges. It was determined that dikes can be designed to avoid high water impacts by having a top elevation below mean high water (similar to what is used on the Middle Mississippi River (MMR). The report describes that although dikes may increase hydraulic resistance, the erosion of the low water bed may compensate for the water level upset entirely. The report also cites conventional practice that requires dikes to be designed so they do not increase stage during high discharges (PIANC 2009). As an engineering organization, the Corps follows this conventional practice and ethical code to ensure that dike construction does not cause an impact to public safety.

2.2 Updated Evaluations

2.2.1 Watson & Biedenharn

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 in 2008. 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 modeling. 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; and (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. A more detailed description of the limitations of early discharge measurements can be found in Watson et al. (2013a).

In their analysis, Watson & Biedenharn (2010) studied the specific gage records at the three rated gages on the MMR: St. Louis, Chester and Thebes. A summary of the analysis techniques used and a detailed analysis of the specific gage record at St. Louis can be found in Watson et al. (2013b). The analysis for the gage at Thebes was omitted 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 were collected by the USGS and retrieved from the USGS website (http://www.usgs.gov).

Bankfull stage at the St. Louis gage is approximately +30 feet with a corresponding discharge of approximately 500,000 cubic feet per second (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 +12 and +16 feet referenced to the St. Louis gage. 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 and 500,000 cfs, a statistically significant horizontal trend in stages was observed. At 700,000 cfs a non-statistically significant, slightly increasing trend in stages was observed. 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 approximately +27 feet 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 +14 to +17 feet referenced to the Chester gage. All structures are completely submerged at discharges exceeding 280,000 cfs. The only statistically significant trend found was a slightly decreasing trend for streamflows below 100,000 cfs. There was a horizontal 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 1973. This year was significant because (1) 1973 was marked by the occurrence of a major flood event that is documented as having significant impacts on the morphology of the MMR, (2) the year 1973 marked the end of a remarkably flood free period and (3) the pre-1973 period was characterized by extensive dike construction whereas the post-1973 period saw 50% less dike construction. 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 (statistically significant) and 700,000 cfs (not statistically significant) 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 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 (Sukhodolov, 2013; Watson & Biedenharn 2010; USGAO 2011, PIANC 2009, Azinfar & Kells 2007, Stevens et al. 1975, Chow 1959).

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.”

2.2.2 United States Geological Survey

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 at St. Louis and +22 feet at Chester. At these stages the navigation structures are submerged by 5-13 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. This study is further evidence of the overestimation of early discharges.

2.2.3 *Statistical Evaluation*

A critical review of the statistical analysis used to support specific gage analyses by Pinter et al., (2001) and Pinter and Thomas (2003) was conducted by V.A. Samaranayake (2009) from the department of Mathematics and Statistics at Missouri University of Science and Technology. Samaranayake (2009) concluded that the analysis presented by Pinter et al., (2001) and Pinter and Thomas (2003) did not support the conclusions that river training structures are increasing stages for higher discharges. In an evaluation of the two types of specific gage analysis, Samaranayake (2009) concluded that the direct step method was the most appropriate on the MMR. This is due to the data points being more homogeneous than those obtained from the rating method as far as variance is concerned and therefore they can be considered devoid of simultaneity bias and other such artifacts.

Samaranayake (2009) also found that, when using computed daily discharge values, the researcher is essentially recreating the original USGS rating curves used to obtain the daily discharges. The computed daily discharge data lacks the natural variability found in measured streamflow and can lead to conclusions that are due to artifacts created by errors in the original rating curves. This error is compounded by the fact that the USGS uses the same rating curves for several years producing results that, rather than being independent, are correlated across several years.

Samaranayake (2009) questioned the cause and effect relationship concluded by Pinter et al., (2001). The straight trend lines concluded by Pinter et al. (2001) revealed an increasing trend in stages reflecting a smooth gradual increase. Dike construction was not constant throughout history. The history of dike construction revealed much variability in magnitude throughout the period of record and did not directly correlate with the trends observed by Pinter (2001). Pinter et al., (2001) failed to prove that the relationship between stage trends on the MMR and dike construction was statistically significant.

2.2.4 Numerical and physical modeling studies

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) modeling software (Piotrowski 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 in two post-construction scenarios.

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 the natural variability in the stage and discharge relationship and decreased with increasing flow/submergence. The study also found that there was no direct cumulative effect for up to four structures.

2.2.5 Analysis of Updated Evaluations

Dike elevation information relative to the gages at St. Louis, Chester and Thebes are important in the interpretation of the specific gage results. On the MMR, dike elevations are well below the top-bank elevations and are submerged by over thirty feet during major floods. The most dramatic impacts of the dikes are expected to be observed in the low to moderate stages below top bank (Sukhodolov, 2013; Watson & Biedenharn, 2010; USGAO, 2011; PIANC, 2009; Azinfar & Kells, 2007; Stevens et al., 1975; Chow 1959). Once the flows spill overbank, the specific gage trends are impacted by changes in the floodplain including bridge abutments, levee construction, vegetation changes, etc. (Huizinga 2009, Heine and Pinter 2012). The effect of levees on the stages of larger floods is more pronounced than at lesser floods due to the additional conveyance loss of the floodplain (Simons et al. 1975, Heine and Pinter 2012).

The magnitude of the stage changes for overbank discharges observed by Watson & Biedenharn (2010), Watson et al. (2013), and Huizinga (2009) are consistent with the expected changes due to the construction of levees along the MMR. The Upper Mississippi River Comprehensive Plan (USACE 2008) calculated that levees contributed an increase of up to 2.9 feet at St. Louis, Missouri and up to 7.3 feet at Chester, Illinois of the 1% annual chance exceedance flood (100-year). The Floodplain Management Assessment of the Upper Mississippi River and Lower Missouri Rivers and Tributaries report (USACE 1995) calculated that agricultural levees contributed an average peak stage increase of up to 4.9 feet on the MMR between St. Louis and Cape Girardeau. The Mississippi Basin Model (MBM) tests showed an increase of up to 4 feet compared to 1820 conditions, depending on discharge and location of flooding (Dyhouse 1995). The magnitude of levee impact is dependent on the roughness of the floodplain being protected. The values detailed above generally assume agricultural land.

Through the use of numerical and physical models, Piotrowski (2012) and Brauer (2013) reinforced the conclusion that river training structures do not impact flood flows. Additionally, Piotrowski (2012) and Brauer (2013) quantified the impact of natural variability in the channel on stage. Brauer (2013), through the use of a moveable bed model, demonstrated the importance of sediment transport and bed changes when analyzing how river training structures influence stages.

3. Analysis of research proposing a link between instream structures and an increase in flood levels.

The Corps has researched and analyzed all available literature that either purports or has been claimed to purport that river training structures increase flood heights. Comments received on the draft Environmental Assessment have provided a list of 51 studies claimed to link the construction of instream structures to increases in flood levels. However, only 21 of the 51 journal articles, technical notes, book chapters, and conference papers cited attempt to link the construction of instream structures to increases in flood levels. The remaining thirty studies cited do not discuss the construction of instream structures and/or increases in flood levels. Some of the cited papers simply reference the research of others as background information. Others discuss the topics of flow frequency, physical modeling and model scale distortion, and levee construction. Others are on topics unrelated to instream structures and/or flood levels.

This appendix only discusses in detail the journal articles, technical notes, book chapters, and conference papers whose conclusions claim a link between instream structure construction and an increase in flood levels. Some of the analyses are presented in multiple papers. Since the analysis in Pinter et al. (2000) is the basis for Pinter et al. (2001a), Pinter et al. (2001b), Pinter et al. (2002), Pinter et al. (2003), Pinter and Heine (2005), Pinter et al. (2006b) and Szilagyi et al. (2008), only Pinter et al. (2000) will be discussed in detail. Similarly, the analysis in Jemberie et al. (2008) is the basis for Pinter et al. (2008), Pinter (2009), and Pinter et al. (2010). Only Jemberie et al. (2008) will be discussed in detail.

The studies whose conclusions claim a link between instream structure construction and an increase in flood levels have been grouped below into three categories: specific gage analysis, numerical simulations and physical fixed bed modeling.

3.1 Specific Gage Analysis

Fifteen of the journal articles, technical notes, book chapters, conference papers and editorials proposing a link between instream structures and an increase in flood levels rely on the use of specific gage analysis.

3.1.1 Description

Specific gage analysis is a graph of stage for a specific fixed discharge at a particular gaging location plotted against time (Watson et al 1999). The use of specific gage analysis is a simple and straightforward method to illustrate aggradation and degradational trends in a river or the response of a river to various alterations in the channel. Similar to most engineering analyses, the interpretation of specific gage records can be complex.

Specific gage analysis is an analysis of field data collected at gage locations along a river. The measurements that are collected at the gage locations are stage (water height), velocity (speed of the water) and cross sectional area (area of the channel). Velocity and area are multiplied together to calculate the discharge which is the volume of water passing a fixed location. It is important to ensure that the methodology and instrumentation used to collect velocity and cross sectional area has not changed during the period of record being examined. If it has changed, it is important to understand how those changes in instrumentation and methodology impact the results. As detailed above, the period of record on the MMR includes two distinctly different data sets.

3.1.2 Papers using specific gage analysis to link instream structure construction to flood level increases

The first use of specific gage analysis to link instream structures to apparent changes to the stage-discharge relationship on the Middle Mississippi River dates back to Stevens et al. (1975) and Belt (1975). Flaws in the source data, methodology and analysis used by Stevens et al. (1975) were addressed by Stevens (1976), Dyhouse (1976) Strauser & Long (1976) and Westphal & Munger (1976). These include the following: use of limited cross-sectional data from one highly engineered reach of the MMR (St. Louis harbor) to represent the entire Middle Mississippi River; use of the unmeasured 1844 flood discharge and the 1903 flood discharge, which was measured only at Chester and Thebes using a different analysis to draw sweeping conclusions; use of early inaccurate and overestimated discharge measurements in conjunction with more accurate contemporary measurements; and the lack of a direct correlation between dike construction and trends in water surface changes.

Through a comparison of trends in stage and streamflow measurements from floods from 1862-1904 to those after the 1980s, Criss & Shock (2001) concluded that stages have increased over time on rivers due to the construction of river training structures. Criss & Shock (2001) also analyzed rivers with and without river training structures to determine the impact structures have on water surfaces. The conclusions of Criss & Shock (2001) are driven by the comparison of two distinctly different data sets: early discharges collected by the Corps and contemporary discharges collected by the USGS. As detailed above, combining early Corps discharge measurements with contemporary USGS discharge measurements without appropriately accounting for the differences in accuracy of those measurements can result in flawed conclusions.

Pinter et al. (2000) used specific gage analysis to study changes to the stage-discharge relationship, cross-sectional area and velocity on the Middle Mississippi River. A specific gage trend was developed using daily stage and discharge data from the Middle Mississippi River gages at St. Louis, Chester, and Thebes. Pinter et al. (2000) concluded that engineering modifications on the Middle Mississippi River have caused changes in the cross-sectional geometry and flow regime leading to a decrease in stages for low discharges and rising stages for water levels starting at 40%-65% of bankfull discharge and above. Since their analysis shows rises in stages are greater for larger discharges, the authors conclude that the impact of the changes is greatest for large flood events.

One limitation of specific gage analysis is that it can only be performed on rated gages (gages with a discharge record). Jemberie et al. (2008) developed a refined specific gage approach attempting to overcome this limitation by developing “synthetic discharges” at stage only gages. The synthetic discharges were created by interpolating discharge values at nearby gages to create a stage- discharge relationship at stage only gages. Rare discharges were created using “enhanced interpolation” to formulate a continuous specific gage time series for large, rare discharges. 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).

3.1.3 Errors in specific gage papers

3.1.3.1 Use of a non-homogeneous data set

The analysis in Pinter et al. (2000) and Jemberie et al. (2008) includes data, assumptions and analysis techniques that have been brought into question by engineers and scientists within the Corps, USGS and academia. The period of record data set used by Pinter et al. (2000) and Jemberie et al. (2008) combines daily discharge measurements from rating curves developed by both the Corps of Engineers and USGS. The use of daily discharge data from the entire period of record implies the assumption that the rating curves have been developed using the same methods throughout the period of record and the measured discharges used to develop the rating curves were collected similarly throughout the period of record. On the MMR, this assumption is not valid since the period of record of discharge measurements is two distinctly different data sets as discussed above.

In an effort to disprove the long standing joint conclusion of the Corps and USGS that Corps measurements overestimated discharges compared to the USGS standard used after 1933 (Ressegieu 1952, Huizinga 2009, Watson et al. 2013a, Dyhouse 1976, Dyhouse 1985, Dyhouse 1995, Dieckmann & Dyhouse 1998), Pinter (2010) analyzed 2,015 measurements collected by the Corps on the Middle Mississippi River. The author concluded that early Corps discharges were not overestimated but were, in fact, underestimated. Based on this faulty conclusion, the author questions the adjustment of early data in the Upper Mississippi River System Flow Frequency Study and the flood frequencies and flood profiles used by the Corps on the Middle Mississippi River.

Pinter (2010) did not analyze a data set sufficient to prove his hypothesis. The source data used by the author, *Corps of Engineers, 1935, Stream-flow measurements of the Mississippi River and its Tributaries between Clarksville, MO., and the Mouth of the Ohio River 1866-1934*, included only early Corps measurements using different instruments and methodologies employed by the Corps. The author did not analyze any measurements collected using USGS instruments and methodology or compare any early Corps measurements to ones collected by the USGS.

3.1.3.2 Use of Daily Discharge Values

The analysis by Pinter et al. (2000) used daily discharge values instead of measured discharges. Daily discharge values are values of discharge that are extracted from the rating curve using a measured value of stage for a specified gage location. A rating curve is a relationship between stage and discharge that is developed by creating a smooth equation using observed measured data. Rating curves usually incorporate data from multiple years to develop their relationship and therefore are not reflective of the river for one particular year.

The use of daily discharge data over direct measured discharges for the creation of a specific gage record is discouraged by many experts including Stevens (1979), Samaranayake (2009), Huizinga (2009) and Watson and Biedenharn (2010). Stevens (1979) recommended that "measured discharges should gain quick acceptance over estimates obtained from rating curves because they reveal the relationship that exists between discharge and the controlling variables at the time of measurement.” Samaranayake (2009) cautioned against the use of data obtained from rating curves since “such data lacks the natural variability one finds in actual data and can lead to conclusions that are due to the artifacts created by errors in the original rating curves.” Watson and Biedenharn (2010) acknowledged that it is often tempting to use the computed daily discharge values since they increase the number of data points and improve the statistics of the rating curve, but caution that these values are not valid and risk masking actual trends.

3.1.3.3 Analysis of early Corps and USGS rating curve development

Compounding the issues with using daily discharge measurements is the use of rating curves developed by multiple agencies using different standards and practices. Over the sixty-six years between 1861-1927, the Corps created five independent rating curves for the St. Louis gage. Curves were developed for the time periods 1861-1881, 1882-1895, 1896-1915, 1916-1918 and 1919-1927. Each curve was created with discharges collected within that time period. In most cases, the discharge measurements were not collected continuously through the rating period. For example, the first rating period which spans 1861 to 1881 was created using only 181 discharge measurements. All but four of the measurements were made in 1880 and 1881 (Huizinga 2009).

The rating curves employed by the USGS (starting in 1933 in St. Louis) are not as static as the early ratings used by the Corps. USGS rating curves are often shifted and changed to account for changes in the shape, size, slope and roughness of the channel. To keep the ratings accurate and up to date, USGS technicians visit each streamgage about once every 6 weeks to measure flow directly. The USGS also emphasizes measuring extreme high and low flows since they are less common and can greatly impact the ends of the rating curve.

Regardless of whether the early Corps or contemporary USGS rating curves are used, daily discharge measurements extracted from a rating curve do not represent the characteristics of the river at the gage location for a particular year. To analyze changes over time it is recommended to create independent annual rating curves using measured discharges all collected in a specific year or analyze measured discharges for specific discharge ranges over time.

3.1.3.4 Statistical Errors

There are significantly fewer points associated with the larger discharge values of the specific gage records than the more frequent discharges. For example, as of March 2014 there have been approximately 3,435 discharge measurements collected at the St. Louis gage since 1933. Only 253 measurements (7.4 percent) have been collected for flows above bankfull (500,000 cfs). Only 80 measurements (2.3 percent) have been collected for flows above 700,000 cfs. Forty percent of the measurements observed for flows greater than 700,000 cfs were collected during the 1993 flood.

When using the direct step method of specific gage analysis, the uncertainty for the flows with limited data is revealed in the statistics (Watson & Biedenharn 2010). Pinter et al. (2000) used the rating curve method of specific gage analysis using daily discharge which the author called “a powerful tool for reducing scatter in hydrologic time-series” (Pinter 2001). As with most dependent variable values predicted using a regression equation, the error in the regression equation is less close to the mean of the independent variable and increases toward the more extreme values (small and large discharge values). The net result is that Pinter et al. (2000) generated data that has varying degrees of error variance and the use of ordinary least squares estimation under such circumstances has lead to incorrect results (Samaranayake 2009).

3.1.3.5 Physical Changes on the MMR

Inherent in the use of a specific gage that spans a long time period is the understanding that errors and inconsistencies associated with the measurement of discharge and stage are captured in the record. Substantial changes in the river, if not accounted for, would all render the specific gage record unreliable.

For example, Pinter et al. (2000) uses a single linear regression to represent the trend for a given discharge value curve. This is problematic since it does not accurately represent all the time periods in the record. There are shorter periods of time observed in the presented specific gage records when stages are decreasing rather than increasing, and the linear trend sorely misrepresents the observed changes. Other problems with this approach are there were major physical changes that occurred throughout the period of record which are reflected by changes in the stage-discharge record. These include the capture of the Kaskaskia River which shortened the MMR by 5 miles, the construction of reservoirs which reduced the sediment load in the MMR, and the construction of levees throughout the period of record including the completion of the Alton to Gale levee system.

3.1.3.6 Creation and use of "Synthetic Discharges" and "enhanced interpolation"

Much of the analysis of Jemberie et al. (2008) is similar to the analysis of Pinter et al. (2000) and has the same issues as described above. The new contributions of Jemberie et al. (2008) are the development of 'synthetic discharges' for unrated gages and 'enhanced interpolation' to calculate continuous specific-stage time series for rare discharges.

The development of 'synthetic discharges' is simply the development of a discharge record for gages where discharge was not measured by interpolating between rated gages. The purpose of creating a discharge record is so a specific gage analysis can be performed at that gage. Since the discharge record at the 'synthetic gages' is inherently dependent on the discharge record at the legitimately rated gages, the data at the 'synthetic' gages are not independent and should not be treated as such. The creation of a rating for the 'synthetic gages' incorporates an abundance of uncertainty due to the many assumptions that need to be made.

Compounding the problems with interpolating between gages to create a discharge value at an unrated gage is the use of daily discharges as the source data for the interpolation. As detailed above, daily discharges are not measured values. The use of daily discharge values incorporates more error and uncertainty into the fabricated rating at the 'synthetic gages'.

For rare high flows, the true rating curve for an unrated gage may be heavily influenced by levee overtopping or other phenomena which would only be reflected through discharge measurements. The author does not detail or account for the impact of the assumptions made on the 'data' created for the 'synthetic gages'.

The practice of using 'enhanced interpolation' to generate a continuous time series for a particular fixed discharge is not supported by the Corps and many other engineers and scientists. Similar to the 'synthetic gage' data, the data created using 'enhanced interpolation' is based off of an interpolation scheme and is not measured data. The fabricated values are dependent on the other values used to create the time series trend.

To create the data using 'enhanced interpolation' one must assume that the time series for Q and Q_t^* is continuous and linear. Watson et al. (2013b), Watson and Biedenharn (2010), Huizinga (2009) and Brauer (2009) have all shown that this assumption is not valid. Another assumption necessary is that there is only one specific stage value for each independent discharge, specifically at the highest and lowest discharges. Analyses of measured discharges have shown that stage is dependent not only on discharge but other physical characteristics of the channel (bed roughness, vegetation, sediment load, temperature, etc.). The use of 'enhanced interpolation' masks the natural variability in the relationship between stage and discharge.

Jemberie et al. (2008) does not make any attempt to verify the validity of the 'enhanced interpolation' technique by proving the relationship using stage and discharge relationships at rated gages.

3.1.4 Summary

A majority of the journal articles, technical notes, book chapters, and conference papers whose conclusions claim a link between instream structure construction and an increase in flood levels rely on specific gage analysis. The specific gage analyses that conclude that instream structures impact flood levels are all driven by the use of source data and methodology not supported by many engineers and scientists in the fields of river data collection, river engineering, geomorphology, hydraulics and statistics. Specific gage analysis studies conducted on the MMR also conclude that instream structures do not impact flood levels (Huizinga 2009, Watson & Biedenharn 2010 and Watson et al. 2013). The Corps does not give credibility to the conclusions of the specific gage analysis studies that attempt to link instream structures with increases in flood level due to the methodology and data use errors.

3.2 Papers using numerical simulations to link instream structure construction to flood level increases

3.2.1"Retro-Modeling"

Remo and Pinter (2007) developed a one-dimensional unsteady-flow "retro-model" of the Middle Mississippi River using historical hydrologic and geospatial data to assess the magnitude and types of changes in flood stages associated with twentieth century river engineering.

Comparison of the retro-model results with the 2004 Upper Mississippi River System Flow Frequency Study (UMRSFFS) revealed increases in flood stages of 0.7 – 4.7 m. The difference in flood stages between the UMRSFFS and retro-model increased with increasing discharge.

3.2.1.1 Errors in "Retro-Modeling" studies

3.2.1.1.1 Source Data

The large stage differences between current and early discharge estimates are partly due to the use of incorrect discharge values for historic hydrographs and floods occurring prior to 1933 as discussed above. The retro-modeling period of 1900-1904 includes one major flood in 1903 and a small one in 1904. The original estimated historic discharge of 1,020,000 cfs at St. Louis is used for the peak of the 1903 flood. This flow was originally developed for St. Louis from discharge measurements made at Chester. Tests conducted with the Mississippi Basin Model in the late 1980s found that a match of the 1903 high water marks through the entire reach of stream at St. Louis occurred for a discharge of about 790,000 cfs. The actual value of the 1903 discharge at St. Louis is likely to be approximately 230,000 cfs (or 23 percent) less than the value used by Remo and Pinter (2007) in the model calibration.

3.2.1.1.2 Channel Roughness

Manning's 'n' is the value most often modified to achieve a calibration of the model results to known stages. Manning's 'n' represents the relative roughness of a channel. The larger the Manning's 'n' the more resistance there is to flow. Forcing a calibration of the high and incorrect discharge of the 1903 flood would require a surprisingly low 'n' value for the channel of about 0.02, as used by Remo and Pinter (2007). The authors observe that the 'n' values for the historical period were systematically at the lower end of the published ranges. In practice, this usually indicates a problem with the model geometry or input data.

The authors describe HEC-RAS as only allowing a single roughness coefficient value in the channel and separate values for the floodplains. The limitation of having "fixed" values was described as a source of model uncertainty. This statement by the authors is untrue — not only does HEC-RAS have the ability to vary the 'n' value horizontally across the cross sections, but it can also be varied for flow or season. All of these techniques are standard hydraulic engineering practice. Horizontal variation of the roughness may be necessary to generate reasonable model results and has a solid foundation in the literature, as noted by Remo and Pinter (2007).

3.2.1.1.3 Model Assumptions

One assumption that could affect model results is the absence of flows from tributaries in the model calibration. Another problematic model assumption is that land use in unmapped areas was forested. Large tracts of timber in the Mississippi Valley were harvested in the late 1800s and early 1900s. The 'retro-model' also does not appear to consider how under the natural (before levee construction) conditions, flood water entering the floodplain over natural levees likely returned to the channel through a series of backwater swamps and channels. This may explain the apparent tendency of the model to over predict stages on the falling limb of the hydrograph. This natural drainage system was likely altered during conversion of the floodplain to agricultural production.

3.2.1.2 Corps Conclusions and Analysis

The calibration of the "retro-model" has been questioned by the Corps due to the use of early Corps discharges, surprisingly low 'n' values used, and other model assumptions detailed above. The Corps believes that the surprisingly low Manning's roughness values were necessary to compensate for the overestimated flows used in the model and are not representative of the characteristics of the historic channel.

The Corps takes the conclusions of Remo & Pinter (2007) very seriously and has attempted to work with the authors to verify the model results and gain a full understanding of the physical processes driving their concluded increase in flood stage. This research was carried out with support from the US National Science Foundation (NSF) grants EAR-0229578 and BCS-0552364. National Science Foundation policy states that, "Investigators are expected to share with other researchers, at no more than incremental cost and within a reasonable time, the primary data, samples, physical collections and other supporting materials created or gathered in the course of work under NSF grants." However, to date, the authors have refused to provide the model, data or any other supporting materials to the Corps' St. Louis District, although multiple requests for this information have been made.

3.2.2 Retro and Scenario Modeling

Remo et al. (2009) is an expansion of Remo and Pinter (2007). In addition to the comparison of the 'retro-model' to the UMRSFFS, Remo et al. (2009) run a series of scenario models to quantify the impact of levees, channel change and land cover. Remo et al. (2009) concluded that on the MMR in the "St. Louis Reach" levees accounted for 0.1 – 1.0 m of increase in stage, changes in channel geometry accounted for a stage increase of 0.1-2.9 m, changes in total roughness accounted for a stage increase of 0.1 – 1.4 m, and changes in land cover accounted for a stage increase of up to 0.4 m.

Similar to the model effort of Remo and Pinter (2007), the Corps has attempted to work with the authors to verify the model results and gain a full understanding of the physical processes driving their concluded increase in flood stage. To date the authors have refused to provide a copy of the model and associated data used to develop the conclusions of Remo et al. (2009) for review by the Corps in spite of the NSF policy requirements detailed above. This research was funded by NSF Grants EAR-0229578 and BCS-0552364.

Remo et al. (2009) concludes that "changes in total roughness (channel and floodplain Manning's n) between the ca. 1900 retro-model and the values used in the UMRSFFS UNET model explained much of the increases in stage observed along St. Louis Study reach." The Corps believes these stage changes are due to errors in the modeling process as detailed above and are not representative of physical changes on the MMR.

3.2.3 Theoretical Analysis

Huthoff et al. (2013) used a simplified theoretical analysis to test the impact of wing dikes on flood levels. This analysis used a simplified cross section to test three scenarios: with no wing dikes, with wing dikes without bed response, and with wing dikes including bed response. The overall channel discharge is calculated for each stage using Manning's equation for steady uniform flow. The discharge for separate flow compartments is calculated using the divided channel method. The Manning's roughness for the dike region is calculated using a flow resistance equation from Yossef (2004, 2005). The author concludes that although the roughness in the dike reach decreases with increasing water levels, the submergence is not great enough for the roughness to return to the base roughness. The authors conclude that the increase in stage for four times the average flow ($4Q_{ave}$) due to the wing dikes is 0.6 m, 0.7 m, 1.1 m and 0.6 m at St. Louis, Chester, Grand Tower and Thebes, respectively.

3.2.3.1 Errors in Theoretical Analysis

3.2.3.1.1 Applicability of Effective Roughness Equation

The theoretical analysis proposed by Huthoff et al. (2013) is an oversimplified method to quantify an extremely complex and dynamic hydraulic problem. The basis of this analysis is the effective 'n' value formula developed by Yossef (2004, 2005) which was developed using a fixed bed physical model scaled to represent a reach of the Dutch River Waal which has much different geometry, dike size, and dike spacing than those used on the Middle Mississippi River. Although this relationship can be used to give insight into the effective roughness in the dike zone and submergence, it is only suitable to deduce trends rather than quantify accurate magnitudes of change.

3.2.3.1.2 Bank Roughness

As detailed in the editor's note, Huthoff et al. (2013) initially submitted a manuscript with an error in the calculation of Manning's roughness which resulted in an overestimation of the roughness by a factor of 10. Due to the theoretical model's sensitivity to the bank roughness value, this overestimation was the primary driver for the stage changes concluded. A simple correction of the calculation error with no additional manipulation in input data results in stage changes of -0.12 m at St. Louis, +0.21 m at Chester, +0.84 m at Grand Tower, and -0.00 m at Thebes for $4Q_{ave}$. In addition to correcting the error, the authors changed the input values of bank roughness, mean dike crest elevation, and assumed bed level changes. The impact of each of these input changes in the model was an increase in stage for $4Q_{ave}$.
The bank roughness values used in Huthoff et al. (2013) were much lower than what is typically used for the MMR and much lower than those used for the main channel. The authors used a combination of 'n' values from different sources: the bank values were arbitrarily taken from literature whereas the values for other zones were taken from a hydraulic model. This resulted in velocity distribution in the channel that had high velocities along the bank and lower velocities in the channel at high flow. This is contrary to observed and theoretical velocity patterns in an open channel (Chow 1959).

3.2.3.1.3 Model Verification

The model used in this analysis did not have adequate validation to prove that it has the ability to reproduce empirical results. The attempt of validation showed that the model matched the empirical values which it was calibrated to. The author did not validate the model to an independent observed flow which is customary engineering practice. The author also did not attempt to verify the ability of the model to reproduce any flood flows.

3.2.3.2 Discussion

Since the relationship by Yossef (2004, 2005) was developed studying a river whose geometry and structures are very different to those used on the MMR, it cannot be used to quantify accurate magnitudes of change on the MMR. Although the model used by Huthoff et al. (2013) has many limitations preventing it from being used quantitatively, insight can be gained by the shape of the relationship between water level and dike roughness. The reduction of roughness with an increase in submergence is consistent with what has been observed by many scientists and engineers (Sukhodolov 2013; Watson & Biedenharn 2010; GAO 2011; PIANC 2009; Azinfar & Kells 2007; Stevens et al. 1975; Chow 1959) and in conflict with what has been concluded by Pinter (2000) and Remo & Pinter (2007).

3.3 Physical Fixed Bed Modeling

Azinfar and Kells (2009, 2008, and 2007) use the results of fixed bed physical model studies to analyze flow resistance and backwater effect of a single dike. The authors use the conclusions of Criss & Shock (2001), Pinter et al. (2001) and Pinter (2004) as a foundation for their research. The purpose of the analysis in Azinfar and Kells (2009, 2008, and 2007) was to "quantify the amount of backwater effect that occurs so that the impacts of spur dike construction can be determined by those charged with managing the river system."

Azinfar and Kells (2007) developed a multi-functional backwater model calibrated to fixed bed physical model studies by Oak (1992) to study the backwater effect due to a single spur dike in an open-channel flow. Parameters analyzed using the model include the spur dike aspect ratio (height/length), spur dike opening ratio (1-length/channel width), spur dike submergence ratio (water depth/height) and upstream Froude number. Azinfar and Kells (2007) found that the parameter that has the greatest effect on the drag coefficient of a spur dike was the submergence ratio— the more the structure is submerged, the less the drag coefficient and therefore the less impact it has on water surfaces. This conclusion is contrary to the conclusion of Pinter (2000) and Remo & Pinter (2007) that conclude that the impact of dikes on water surfaces increases with increasing discharge and are highest at flood stage.

Azinfar and Kells (2008) propose a predictive relationship developed in Azinfar and Kells (2007) that can be used to obtain a first-level estimate of the backwater effect due to a single, submerged spur dike in an open channel flow. Azinfar and Kells (2009) conclude that in a rigid flume an increase in blockage due to a spur dike is the main parameter responsible for an increase in the drag coefficient and associated flow resistance.

There is no debate that in a fixed bed scenario any channel blockage will produce a backwater effect. This is due to the decrease in cross sectional area resulting from the presence of the structure. The conclusions of Azinfar and Kells (2009, 2008, and 2007) reinforce why incorporating sediment transport is critical in having a full understanding of the impacts of dikes on water surfaces, particularly flood levels. The purpose of dikes is to induce bed scour and deepen the channel. Analysis of cross sectional changes on the Mississippi River has shown that once equilibrium is reached, although the dimensions of the channel may be different (i.e., deeper and narrower), the cross sectional area is preserved.

4. Studies cited that do not link the construction of instream structures to increases in flood levels

Other journal articles, editorials and conference papers have been incorrectly referenced as linking the construction of instream structures to increases in flood levels:

1. Chen and Simmons (1986), Roberge (2002), Pinter et al. (2006a), Sondergaard and Jeppesen (2007), Theiling and Nestler (2010), and Borman et al. (2011) simply reference the research detailed in the aforementioned papers as background but do not present any new analysis.

2. Bowen et al. (2003), Wasklewicz et al. (2004), Ehlmann and Criss (2006), Criss and Vinston (2008), Criss (2009) and Pinter et al. (2012) analyze flow frequency and/or propose changes to the way flow frequency is calculated. They do not present any new analysis linking instream structures to increasing flood levels.

3. Struiksma and Klaasen (1987), Ettema and Muste (2004), and Maynord (2006), are about physical modeling and model scaling and distortion and do not discuss instream structure construction or flood levels.

4. Pinter (2005) and Van Ogtrop et al. (2005) present arguments linking the construction of levees to increases in flood levels. These papers do not present any analysis on instream structures and how they impact flood levels.

5. Maher (1964) presents changes in river regime of the Mississippi River and the variations in rating curves with respect to time and stage. The analysis includes causes for some of the stage-discharge relationship changes. The author analyzes the changes of three reaches of the MMR over three different time periods. Maher (1964) concludes that "the construction of levees in the Mississippi River floodplain during the period 1908-1927 has been the main factor in reducing floodway capacity to approximately 54% of the 1908 area. Between 1927 and 1943, when no additional levees were constructed, the floodway capacity remained practically constant, being reduced in area by only an additional ½ of 1%." Maher (1964) does not attempt to link the construction of instream structures to increases in flood levels.

6. Paz et al. (2010) describes a HEC-RAS model study of the Paraguay River and its tributaries with limited data.

7. Doyle and Havlick (2009) examines current infrastructure and current understanding of environmental impacts for different types of infrastructure. This paper discusses the impact of levees on flooding.

8. Remo et al. (2008) discusses a database compiled by the authors with hydrologic and geospatial data on the Mississippi, lower Missouri and Illinois rivers. No analysis is conducted or conclusions drawn.

9. Remo and Pinter (2007) is a conference paper that discusses the database compiled by the authors detailed in Remo et al. (2008) and summarizes "retro-modeling" as a tool to analyze historic changes.

10. O'Donnell and Galat (2007) discusses river enhancement projects on the Upper Mississippi River and recommends improvement in management practices and project data collection, entry, management, and quality control/assurance across agencies.

11. Jai et al. (2005) used CCHE3D, a three-dimensional model for free surface turbulent flows developed at the National Center for Computational Hydroscience and Engineering, to study the helical secondary current and near-field flow distribution around one submerged weir. The model was validated using flow data measured during a physical model study conducted at the Coastal and Hydraulic Laboratory of ERDC. The models used in this study did not simulate sediment transport and channel change. Although water surface elevation contours are discussed near the submerged weir, the paper does not present a detailed analysis of the structures' impact on water surfaces.

12. Pinter et al. (2004) provides an evaluation of dredging on a particular reach of the Middle and Upper Mississippi River based on dredging records obtained from the USACE St. Louis District. Although references to the impact of river training structures on flood stages are made several times, Pinter et al. (2004) does not have any analysis, discussion or conclusions on the topic.

13. Smith and Winkley (1996) examine the response of the Lower Mississippi River to a variety of engineering activities. This paper presents a brief history of engineering investigation on the Lower Mississippi River, analyzes the impact of artificial cutoffs on the channel geometry and water surface profiles, analyzes the impact of channel alignment activities on channel morphology and the apparent impact of all of the Lower Mississippi River engineering activities on sediment dynamics in the channel. There is no discussion or analysis by Smith and Winkley (1996) on how the construction of river training structures impacts flow levels.

14. Huang and Ng (2006) use a CCHE3D model calibrated to a fixed bed physical model to study basic flow structure around a single submerged weir in a bend. Conclusions are made on the near field changes in water surface. With the weir installed, the water surface elevation reflected the existence of the weir in the whole channel with an increase in the water surface elevation upstream of the weir due to an increase in resistance when the flow approaches the weir. Downstream of the weir the model found a decrease in water surface due to the acceleration of the flow after passing through the weir. Huang and Ng (2006) describe the changes in water

surface as a “local effect.”   The scenario analyzed in Huang and Ng (2006) is for a single weir added to a fixed bed channel with no change in channel bathymetry, thus presenting an obstruction to flow. The author does not test flood flows or attempt to extrapolate his results to conclude that instream structures raise flood levels.

5. Studies the Corps was unable to gain access to

The Corps was unable to retrieve copies of the following study and therefore was unable to use it in their analysis of the impact of instream structures on flood levels:

Clifford, N.J., Soar, P.J., Gurnell, A.M., Petts, G.E., 2002. Numerical flow modeling for eco-hydraulic and river rehabilitation applications: a case study of the River Cole, Birmingham, U.K.. In River Flow 2002, Bousmar D, Zech Y (eds). Swets & Zeitlinger/Balkema: Lisse; 1195-1204.

6. Conclusion

Based upon all of the available research analyzed above, the Corps has concluded that river training structures do not impact flood levels. The research efforts, as detailed in the published papers, book chapters, editorials and conference proceedings that conflict with the Corps' conclusions all rely on analysis, assumptions and data that is not supported by engineers and scientists within the Corps, other Federal Agencies with expertise in water resources, and academia.

The claims in the literature detailed above that river training structures have an impact on flood flows are not new. The Corps was concerned in the 1930s that the construction of dikes may have reduced the floodway capacity of the MMR (Ressegieu 1952). The Corps worked with the USGS and other experts to understand the issue and determined that there was not a change in floodway capacity rather a change in the way data was collected. Through the incorrect use of early Corps discharge data (Watson et al. 2013a) scientists in the 1970s again claimed that dikes have increased flood levels. In response, the Corps worked with experts from academia to understand the issue and study the problem using the latest technology. The conclusions of the experts reinforced previous conclusions that river training structures do not increase flood levels.

Recently, the Corps worked with experts from other agencies and academia to evaluate the impact of river training structures on flood levels. The conclusions of these studies reinforce the previous conclusions that river training structures do not increase flood levels. As has been the case throughout the history of the Regulating Works Project, the Corps will continue to monitor and study the physical effects of river training structures using the most up-to-date methods and technology as it becomes available.

The majority of research attempting to link river training structures to an increase in flood heights is based off of a handful of research efforts primarily by researchers from three academic institutions: Washington University (Criss, Shock), Southern Illinois University –Carbondale (Pinter, Remo, Jemberie, Huthoff), and University of Saskatchewan (Azinfar, Kells). The Corps takes the claims of these researchers very seriously and has made repeated attempts to engage and collaborate with them to fully understand their conclusions that link river training structures to increases in flood levels. These efforts have had limited success (USGAO 2011).

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Appendix B. Biological Assessment

TIER II BIOLOGICAL ASSESSMENT
MOUTH OF THE MERAMEC
MOSENTHEIN REACH – IVORY LANDING, PHASE V
MRM 161 – 162.5
MONROE COUNTY, ILLINOIS
ST. LOUIS COUNTY, MISSOURI
ON THE
MIDDLE MISSISSIPPI RIVER SYSTEM

November 2014

U.S. Army Corps of Engineers
St. Louis District
Planning and Environmental Branch (CEMVP-PD-C)
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TIER II BIOLOGICAL ASSESSMENT
MOUTH OF THE MERAMEC
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ST. LOUIS COUNTY, MISSOURI

1. Programmatic Endangered Species Compliance

A programmatic (Tier I) consultation, 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 (UMRS) and addressed listed species as projected 50 years into the future (U.S. Fish and Wildlife Service 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 a separate Tier II consultation. Although channel structure impacts were covered at the program and ecosystem level under the Tier I consultation, other site and species specific impacts may occur. As such, the Mosenthein Reach – Ivory Landing, Phase V (Mouth of the Meramec) project requires a Tier II consultation.

Mosenthein Reach – Ivory Landing, Phase III (Phase III) and Phase IV also required a Tier II consultation. The Phase III consultation was completed on September 9, 2010 with receipt of a Tier II Biological Opinion provided by Matthew Mangan of the Fish and Wildlife Service. Phase III included placing two traditional wing dikes within the river at RM 182 and placing revetment on unprotected shoreline at RM 171.3 to 173.3. The Corps received a "no effect" and "not likely to adversely affect" decision for listed species, as well as a "not likely to result in incidental take of the pallid sturgeon beyond the amount of incidental take described in the 2000 Biological Opinion".

The purpose of the Phase IV project was to stabilize the shoreline and prevent future erosion in the immediate area of the stabilization in order to maintain a safe and dependable navigation channel. The project involved placing revetment on the unprotected shoreline of the left descending bank between RMs 171 - 172 and between RMs 173.5-175 in the Middle Mississippi River. The Corps received a "no effect" and "not likely to adversely affect" decision for listed species, as well as a "not likely to result in incidental take of the pallid sturgeon beyond the amount of incidental take described in the 2000 Biological Opinion".

Phase V of the project will consist of four bendway weirs on the right descending bank and three dikes on the left descending bank between RMs 161.1 and 162.3.

2. Project Authority

The project is authorized under the UMRS Regulating Works Project that was authorized by the River and Harbor Act of 1930. It consists of a 9-foot deep navigation channel that is not less than 300-feet wide with additional width in the bends. Project improvements are achieved by means of dikes, revetment, construction dredging, and rock removal. This project promotes maintenance of a safe and dependable navigation channel. Project funding will come from the Regulating Works Construction General funding.

3. Project Need

The purpose of the Phase V project weirs is to focus the energy of the water in order to reduce dredging and maintain a safe and dependable navigation channel. The Phase V dikes will promote flow into the side channels. The project involves placing weirs and rock dikes from approximately RM 161 to RM 162.5 in the Middle Mississippi River (Figures 1 and 2 and Table 1).

Figure 1. Mosenthein Reach – Ivory Landing, Phase V Site Location Maps

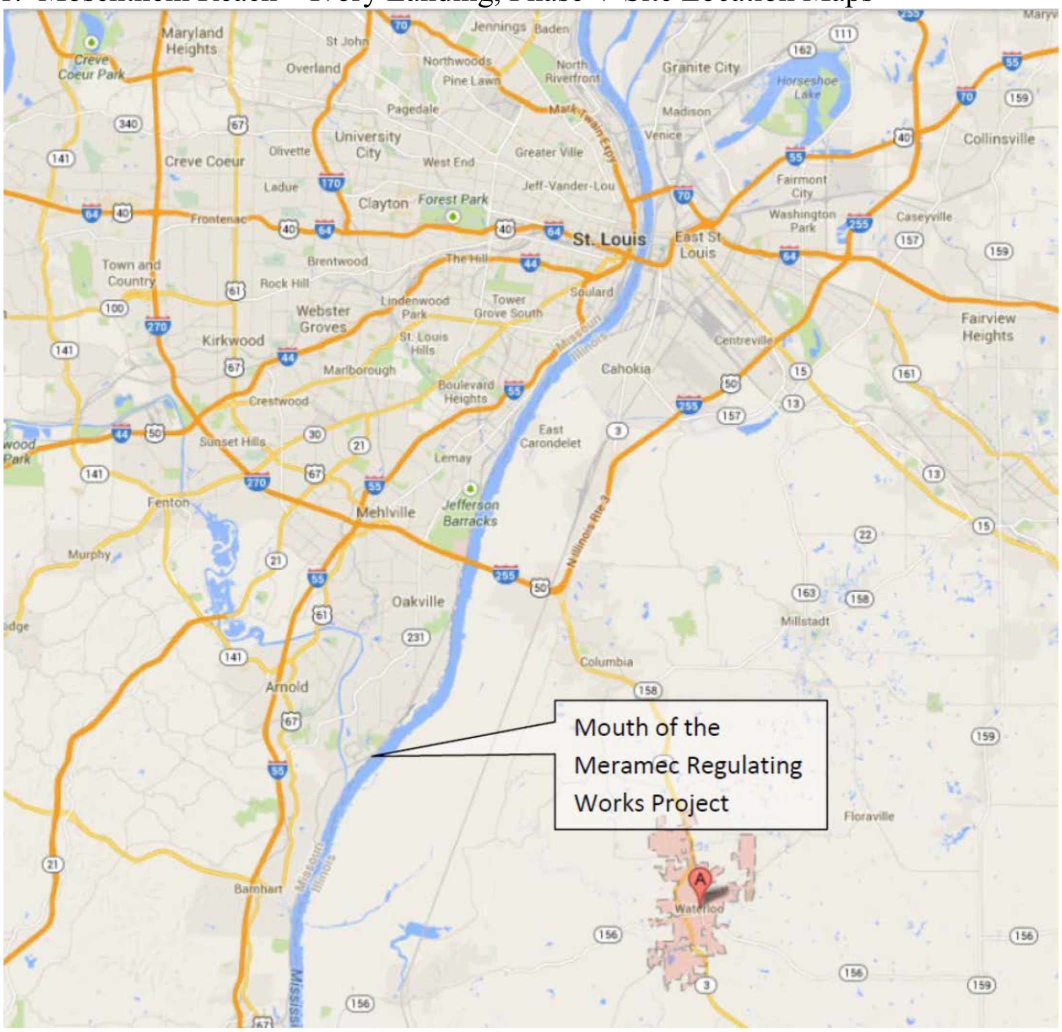


Table 1. Work to be Completed by River Mile and Purpose of Work.

Location by mile	Work to be completed	Purpose
Weir 162.30R Weir 162.20R Weir 162.10R Weir 162.00R	Construct bendway weirs along the right descending bank.	Direct energy of the river toward the thalweg to reduce the need for dredging.
Dike 161.70L Dike 161.50L (Rootless Extension) Dike 161.10L (Rootless Extension)	Construct dikes along the left descending bank.	Two of these are rootless extensions of the existing dikes. They were at angles (and therefore rootless) to provide more environmental diversity than a typical extension.

Figure 2. Mosenthein Reach – Ivory Landing, Phase V Weir and Dike Locations

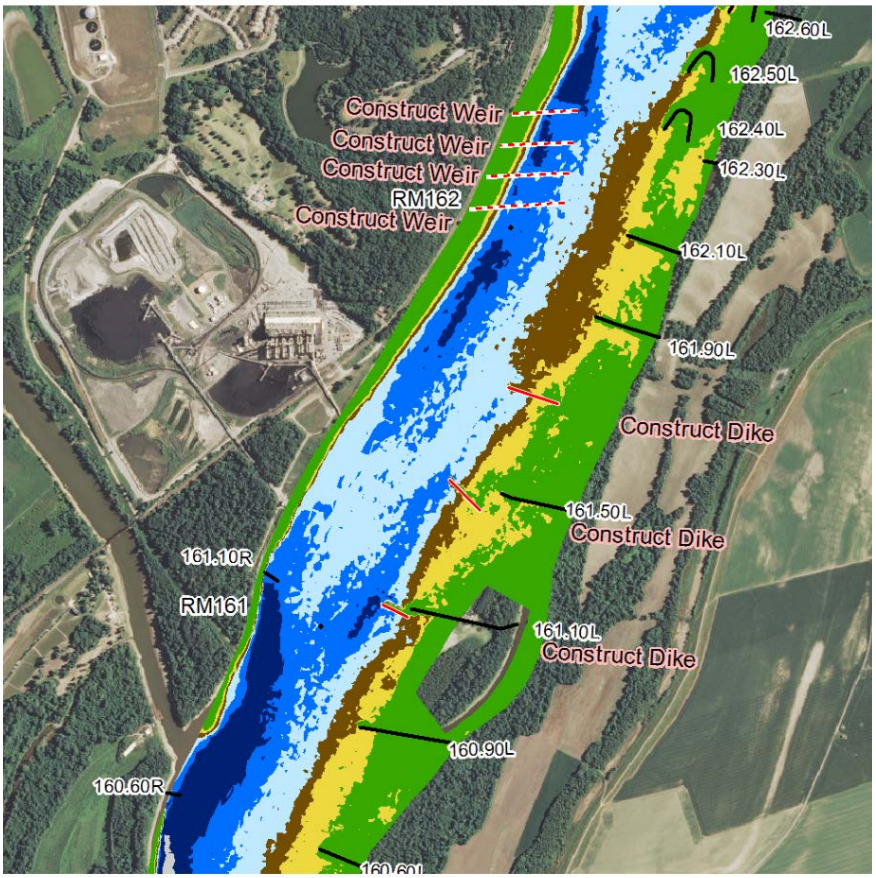
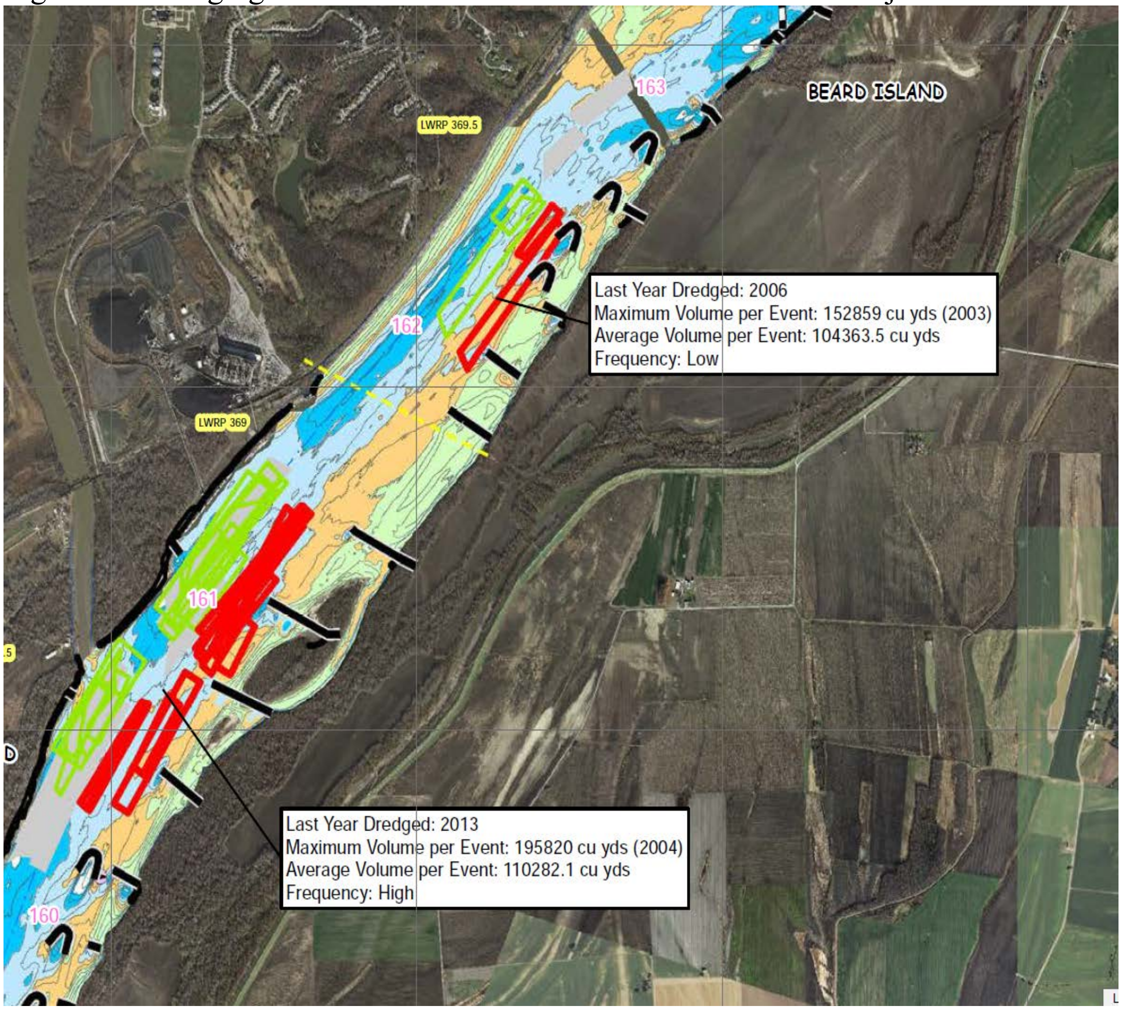


Figure 3 – Dredging and Placement Sites Located in the Phase V Project Area



4. Impact Assessment

The proposed project includes placing weirs between RM 162 – 162.4 and dikes between RM 161.0 – 161.7 in the Mississippi River. The impact of the rock structures is expected to be localized. The weirs and dikes will prevent channel widening and the loss of a safe and dependable navigation channel. Alternative 16, Plate 39, (Figure 2) was recommended as the most desirable alternative because of its observed ability to significantly reduce elevations observed in the repetitive dredging areas between RM 162.00 and RM 160.00 (see Figure 3). This alternative also includes rootless dike structures instead of traditional dikes. This was done in an effort to provide more environmental diversity in the project area. The rootless Dike 161.50 was placed at an angle in an attempt to divert a small amount of additional flow towards the small side channel located along the LDB. It should be noted that throughout testing, no sediment movement was observed within the side channel. Increased water flow into the side channel may improve oxygen levels, water temperatures, waste removal and nutrient levels necessary for a productive fishery. Overall, this alternative enhanced navigation safety for industry by providing a deeper navigation channel while maintaining and potentially improving environmental features within the project area.

5. Species Covered in this Consultation:

A list of species that may occur within the Phase V project area was obtained from the U.S. Fish and Wildlife Information, Planning and Conservation System website on 29 July 2014. Those species are listed in Table 2:

Table 2 - Listed Species That May Occur in the Project Area

Species	Federal Status	Habitat
Gray bat (*Myotis grisescens*)	Endangered	Caves
Indiana bat (*Myotis sodalis)*	Endangered	Hibernacula: Caves and mines; Maternity and foraging habitat: small stream corridors with well developed riparian woods; upland forests
Northern long-eared bat (*Myotis septentrionalis*)	Proposed Endangered	Hibernacula: Caves and mines; Maternity and foraging habitat: the understory of forested hillsides and ridges, small stream corridors with well developed riparian woods; upland forests.
Pallid sturgeon (*Scaphirhynchus albus*)	Endangered	Mississippi and Missouri Rivers.
Least tern (*Sterna antillarum*)	Endangered	Bare alluvial and dredged spoil islands.
Decurrent false aster (*Boltonia decurrens*)	Threatened	Disturbed alluvial soils.
Illinois cave amphipod *(Gammarus acherondytes)*	Endangered	Cave streams in Illinois sinkhole plain.
Mead's milkweed (*Asclepias meadii*)	Threatened	Moderately wet (mesic) to moderately dry (dry mesic) upland tallgrass prairie or glade/barren habitat.
Running buffalo clover (*Trifolium stoloniferum*)	Endangered	This species may be found in partially shaded woodlots, mowed areas and along streams and trails.
Pink mucket (*Lampsilis abrupta*)	Endangered	This species is found in mud and sand and in shallow riffles and shoals swept free of silt in major rivers and tributaries.
Scaleshell mussel (*Leptodea leptodon*)	Endangered	Lives in medium-sized and large rivers with stable channels and good water quality.
Sheepnose mussel (*Plethobasus cyphyus*)	Endangered	Rivers and streams.

Table 2 - Listed Species That May Occur in the Project Area		
Spectaclecase mussel (*Cumberlandia monodonta*)	Endangered	Spectaclecase mussels are found in large rivers where they live in areas sheltered from the main force of the river current. This species often clusters in firm mud and in sheltered areas, such as beneath rock slabs, between boulders and even under tree roots.

<u>Gray Bat</u> (*Myotis grisescens*) - 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.

<u>Indiana Bat</u> (*Myotis sodalis*) - 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). To avoid impacting this species, tree clearing activities should not occur during the period of 1 April to 30 October.

The project areas where rock will be placed are inundated and the rock will be placed using a barge. No trees will be impacted by the project. This project would not result in the destruction of any riparian or forested habitats; therefore, placement of river regulatory structures would have no effect on the Indiana bat.

<u>Northern Long-Eared Bat</u> (*Myotis septentrionalis*) **-** Northern long-eared bats spend winter hibernating in caves and mines. According to the U.S. Fish and Wildlife Service website, northern long-eared bats typically use large caves or mines with large passages and entrances; constant temperatures; and high humidity with no air currents. During summer, northern long-eared bats roost singly or in colonies underneath bark, in cavities, or in crevices of both live and dead trees. Males and non-reproductive females may also roost in cooler places, like caves and mines. This bat seems opportunistic in selecting roosts, using tree species based on suitability to retain bark or provide cavities or crevices. It has also been found, rarely, roosting in structures like barns and sheds. After fertilization, pregnant females migrate to summer areas where they roost in small colonies and give birth to a single pup. Maternity colonies, with young, generally have 30 to 60 bats, although larger maternity colonies have been observed. Northern long-eared bats emerge at dusk to fly through the understory of forested hillsides and ridges feeding on moths, flies, leafhoppers, caddisflies, and beetles, which they catch while in flight using echolocation (USFWS 2014a). This project would not result in the destruction of any riparian or forested habitats; therefore the project would have no effect on the northern long-eared bat.

Pallid Sturgeon (*Scaphirhynchus albus*) - The estimated population of pallid sturgeon in the Middle Mississippi River (MMR) ranges between 1600 and 4900 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 (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 (e.g., upstream island tips within the main channel). These areas provide an ecotone between flow with deposition and 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 (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). 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). According to the Service, this has potentially reduced the availability of pallid sturgeon spawning habitat through the loss of habitat complexity (USFWS 2000).

The weirs associated with Phase V will focus the river's energy to move sediment out of the main sailing line. One of the dikes will direct river flows toward the thalweg and two dikes will deflect flow into a secondary channel to improve the habitat.

Construction activities may result in short-term adverse effects for pallid sturgeon; however, these adverse effects are expected to occur at a localized scale.

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.

Least Tern (*Sterna antillarum*) – This species is a colonial, migratory water bird 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 1999). 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 1999). 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 emergent during the 15 May to 31 August period are potentially available to least terns (USACE 1999). A 1999 report (USACE 1999) estimated that there were approximately 20,412 acres of nonvegetated sandbar habitat above the MMR 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 near Marquette Island (RM 50.5), Bumgard Island (RM 30) (USFWS 2004), and Brown's Bar (RM 24.5-23.5). 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 2000).

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 1999). 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 1999). 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 1999).

In total, the weirs and dikes associated with Phase V may not change the quantity of sandbar habitat in the project area.

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.

Decurrent False Aster (*Boltonia decurrens*) - This species is listed as threatened and is known to occur in several Illinois counties in the floodplain of the Illinois and Mississippi River. It is considered to potentially occur in any county bordering the Illinois River and Jersey, Madison and St. Clair Counties bordering the Mississippi River. It occupies disturbed alluvial soils in the floodplains of these rivers. Federal regulations prohibit any commercial activity involving this species or the destruction, malicious damage or removal of this species from Federal land or any other lands in knowing violation of State law or regulation, including State criminal trespass law. The species' present distribution is likely outside the project area. In addition, the construction activities will be water based. The construction will occur in the river, with no impact to floodplain soils or terrestrial habitats in which decurrent false aster typically occurs. This species is unlikely to be impacted by the project; therefore, this project will have no effect on the decurrent false aster.

Mead's Milkweed (*Asclepias meadii*) - Habitats include mesic to dry tallgrass and upland prairies with sandstone or chert bedrock, prairie hay meadows, railroad rights-of-way, prairie remnants, virgin mesic silt loam prairies, and igneous glades. Historically, Mead's milkweed ranged throughout much of Missouri. It is presently found in the Osage Plains region and the St. Francois mountains region of the Ozarks (MDC 2014). According to the Center for Plant Conservation, all of the tallgrass prairie populations of this species in Wisconsin, Illinois, and Indiana have been destroyed by agriculture, and the only remaining native eastern populations occupy glade habitat in southeastern Missouri and southern Illinois. No tallgrass prairie habitat will be impacted by the project; therefore, this project will have no affect on Mead's milkweed (CPC2014a).

Running Buffalo Clover (*Trifolium stoloniferum*) - According to the Center for Plant Conservation, this plant prefers partly sunny locations with moist, fertile soils that have been exposed to long-term moderate disturbance patterns (including mowing, trampling, and grazing). This plant is often found in the ecotone between open forest and prairie (CPC 2014b). No disturbed prairie will be impacted by this project; therefore, this project will have no effect on the running buffalo clover.

Illinois Cave Amphipod (*Gammarus acherondytes*) – This species inhabits the bottoms of pools and riffles in large cave streams, where they creep among cobbles and under stones. Amphipods feed on small particles of organic debris and on decomposers such as bacteria and fungi. Because they ingest large quantities of this material, they are exposed to contamination from a variety of pollutants. This species is only found in karst caves within 10 miles of Waterloo, Illinois (Monroe County). This species is located ten miles from the project area and no karst caves will be impacted; therefore, the project would no effect on the Illinois cave amphipod.

Pink Mucket (*Lampsilis abrupta*) - This mussel is found in mud and sand and in shallow riffles and shoals swept free of silt in major rivers and tributaries (USFWS 2014b). The pink mucket typically inhabits medium to large rivers with strong currents; however, it has also been able to survive and reproduce in areas of impounded reaches with river/lake conditions without standing water (NatureServe 2014, USFWS 1985). Substrate preferences include sand, gravel, and pockets between rocky ledges in high velocity areas and mud and sand in slower moving waters. Individuals have been found at depths up to one meter in swiftly moving currents and in much deeper waters with slower currents (Gordon and Layzer 1989). Reproduction requires a stable, undisturbed habitat and a sufficient population of fish hosts to complete the mussel's larval development. Live mussels or fresh shells have been observed since 1978 in the Osage, Gasconade and Meramec rivers (MDC 2012). This species is not known to occur in the Mississippi River; therefore, this project should have no effect on the pink mucket.

Scaleshell Mussel (*Leptodea leptodon*) – The scaleshell occurs in medium to large rivers with low to medium gradients. It primarily inhabits stable riffles and runs with gravel or mud substrate and moderate current velocity. The scaleshell requires good water quality, and is usually found where a diverse assortment of other mussel species is concentrated. More specific habitat requirements of the scaleshell are unknown, particularly of the juvenile stage. Water quality degradation, sedimentation, channel destabilization, and habitat destruction are contributing to the decline of the scaleshell throughout its range. As stated in the USFWS' Scaleshell Recovery Plan, the scaleshell, although very rare, can only be consistently found in three Missouri streams including the Meramec, Bourbeuse, and Gasconade rivers (USFWS 2010). The scaleshell is not known to exist in the Mississippi River; therefore, this project should have no effect on the scaleshell mussel.

Sheepnose Mussel (*Plethobasus cyphyus*) – The sheepnose is listed as a federally endangered species and occurs in the Meramec and Bourbeuse rivers in Missouri (MDC 2012). This species inhabits gravel and mixed sand and gravel habitats in medium to large rivers. 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 species is not found in the project area; therefore, this project would have no effect on the sheepnose mussel.

Spectaclecase Mussel (*Cumberlandia monodonta*) – This federally endangered mussel is "known to occur in the Meramec River and may potentially occur in the Mississippi River north of Monroe County, Illinois" (USFWS undated). The spectaclecase is a large mussel attaining 9 to 10 inches in length. Its shell is greatly elongated, compressed, and relatively thin. Its historical distribution includes 45 rivers found in much of the Mississippi River basin, Ohio River system, Cumberland and Tennessee River basins, and part of the lower Mississippi River basin in Arkansas. In Cummings and Mayer (1992), the range for this species as displayed in Illinois and Missouri includes the middle and upper Mississippi River, Illinois River, and an area south of the Missouri River corresponding largely with the Ozark highlands. A distribution map by Oesch (1995) also shows two records from the Mississippi River near Clarksville, Missouri. However, in an assessment of the status of population viability at known locations of occurrence across its range, USFWS (undated) considered all spectaclecase populations in the Mississippi River in Illinois and Missouri to be either extirpated or "non-viable or unknown." None were classified as having "some evidence of viability." Habitat destruction and degradation are the chief causes of imperilment, including reservoir construction, channelization, chemical contamination, mining, and sedimentation. Habitats are found in medium to large rivers with low to high gradients, and include shoals and riffles with slow to swift currents over coarse sand and gravel. Substrates sometimes consist of mud, cobble, and boulders (USFWS 2011). The spectaclecase is not known to exist in the project area, but may occur ten river miles north of the project area. Therefore, the proposed construction would have no effect on the spectaclecase mussel.

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15 May 2015

Reply to:
Regional Planning and Environment Division North
Environmental Compliance Branch (CERPEDN-PD-C)

U.S. Fish and Wildlife Service
Marion Illinois Sub-Office (ES)
8588 Route 148
Marion, Illinois 62959

Attn: Matt Mangan

Dear Matt:

Since the preparation and coordination of the Tier II Biological Assessment for the Mosenthein Reach-Ivory Landing Phase 5 (Mouth of the Meramec) project in late 2014, three new species have been added to the listed species for St. Louis County, Missouri. These include the rufa red knot, piping plover and snuffbox mussel. A supplemental biological assessment for these species has been prepared and is attached.

Please review the attached supplemental biological assessment and provide comments at your earliest convenience.

If you have any questions about this assessment, please contact Mr. Francis Walton of our Environmental Compliance Branch at (314) 331-8102 (Francis.J.Walton@usace.army.mil).

Sincerely,

/signed/
Timothy K. George
Chief, Environmental Compliance Section

Mosenthein Reach - Ivory Landing Phase 5 (Mouth of the Meramec)

Supplemental Biological Assessment (15 May 2015)

The USFWS website (http://www.fws.gov/midwest/endangered/lists/missouri-cty.html) was accessed on May 13, 2015 and the following species were noted for St. Louis Co., Missouri, that were not included in the Mosenthien Reach-Ivory Landing Phase 5 Tier II Biological Assessment dated November 17, 2014 (USACE 2014).

Species	Status	Habitat
Piping plover *(Charadrius melodus)* Northern Great Plains Breeding Population	Threatened	Riverine sandbars
Rufa Red knot *(Calidris canutus rufa)*	Threatened	Shorebird that migrates through Missouri - irregularly observed feeding on mudflats, sandbars, shallowly flooded areas and pond margins along the Missouri and Mississippi Rivers from May 1 through September 30.
Snuffbox (*Epioblasma triquetra*)	Endangered	Small to medium-sized creeks with a swift current

Piping Plover: Piping plovers use wide, flat, open, sandy beaches with very little grass or other vegetation. Nesting territories often include small creeks or wetlands. Piping plovers are migratory birds and occasionally are seen on Missouri shorelines or at wetlands. In the spring and summer they breed in northern United States and Canada. There are three locations where piping plovers nest in North America: the shorelines of the Great Lakes, the shores of rivers and lakes in the Northern Great Plains, and along the Atlantic Coast. In the fall, plovers migrate south and winter along the coast of the Gulf of Mexico or other southern locations (USFWS 2015a).

There is no known piping plover nesting habitat in the project area. This bird is a rare migrant along the Middle Mississippi River, and during migration, exposed sand bars in the project area provide temporary feeding habitat. This project would not eliminate or substantially reduce sandbars within the project area. Therefore, this project would have "no effect" on the piping plover.

Rufa Red Knot: The rufa red knot is a robin-sized shorebird that annually migrates from the Canadian Arctic to southern Argentina. Changing climate conditions are already affecting the bird's food supply, the timing of its migration and its breeding habitat in the Arctic. The shorebird also is losing areas along its range due to development. New information shows some knots use interior migration flyways through the South, Midwest and Great Lakes. Small numbers (typically fewer than 10) can be found during migration in almost every inland state over which the knot flies between its wintering and breeding areas. This shorebird is irregularly observed feeding on mudflats, sandbars, shallowly flooded areas and pond margins along the Missouri and Mississippi Rivers from May 1 through September 30 (USFWS 2015b).

There is no known rufa red knot nesting habitat in the project area. This bird is a rare migrant along the Middle Mississippi River, and during migration, exposed substrates and shallow water in the project area provide temporary feeding habitat. This project would not eliminate or substantially reduce exposed substrates or shallow water within the project area. Therefore, this project would have "no effect" on the rufa red knot.

Snuffbox: Historically the snuffbox mussel was widespread, occurring in 210 streams and lakes in 18 U.S. states and Ontario, Canada. The population has been reduced to 79 streams and lakes in 141 states and Ontario, representing a 62 percent range wide decline. The snuffbox is currently found in Alabama, Arkansas, Illinois, Indiana, Kentucky, Michigan, Minnesota, Missouri, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, Wisconsin, and Ontario, Canada. Most populations are small and geographically isolated from one another, further increasing their risk of extinction (USFWS 2015c). The snuffbox is found in small- to medium-sized creeks, to larger rivers, and in Missouri it is known in the Meramec River, Bourbeuse River, St. Francis River, and Black River.

Since the snuffbox mussel does not occur in the Middle Mississippi River, it does not occur in the project area; therefore, this project would have "no effect" on the snuffbox mussel.

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Appendix C. Cumulative Impacts Analysis

Cumulative Impacts Analysis

The 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 Mosenthein/Ivory Landing Phase 5 EA cumulative impact analysis generally followed the steps laid out by the handbook.

Cumulative impact analysis involved determining the incremental impact of the 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 work area to include impacts to the resources throughout the Middle Mississippi River. Clearly the resources, ecosystem and human environment in the Middle Mississippi River have been, and will continue to be, impacted by a wide range of actions. The cumulative impact analysis evaluates the same resources (Physical Resources [River Stages, Water Quality, and Air Quality]; Biological Resources [Fish and Wildlife: Dike Effects, Bendway Weir Effects, Threatened & Endangered Species, and Climate Change]; Socioeconomic Resources [Navigation]; and Historic & Cultural Resources) that were evaluated in the Environmental Consequences section. In addition, the cumulative impacts for the No Action Alternative and Action Alternative were evaluated for floodplain impacts, navigation effects, and side channel impacts.

The Regulating Works Project, in combination with the other actions throughout the watershed, has had past impacts, both positive and negative, on the resources, ecosystem and 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 includes involving partner agencies throughout the planning process, avoiding and minimizing environmental impacts, and utilizing innovative river training structure configurations to provide fish habitat while still providing benefits to the navigation system. Although our understanding of the actions that bear upon the resources of the Middle Mississippi River continues to evolve, equilibrium in habitat conditions appears to have been reached. Accordingly, only minimal impacts to the resources, ecosystem and human environment are anticipated for the Mosenthein-Ivory Phase 5 project.

A cumulative impact analysis was recently conducted for three Environmental Assessments with signed Findings of No Significant Impact for the Regulating Works Project on the MMR (USACE 2014a, 2014b, 2014c). A comprehensive analysis of the cumulative impacts of the Upper Mississippi River Navigation Project on the geomorphic and biological resources of the UMR has been described in two publications (WEST Consultants, Inc. 2000a, 2000b) prepared for the Programmatic Environmental Impact Statement for the UMR-IWW System Navigation

Feasibility Study (USACE 2004). These studies provided a cumulative effects analysis of the 9-foot Navigation project for the entire UMR and the MMR. West Consultants, Inc. (2000a) provided a geomorphic assessment of the cumulative effects on geomorphology, sediment transport, and dredging. West Consultants, Inc. (2000b) provided a biological assessment of the cumulative effects of geomorphic changes, physical habitat changes, impoundment and river regulation, channel training structures, dredging and material placement, the Environmental Management Program habitat projects, connectivity of UMRS habitats, changes in the UMRS Basin, changes in UMR floodplain land use and land cover, effects of both point and non-point-source discharges to UMRS, fish entrainment and impingement at electrical generating plants, and exotic and nuisance species. In addition, the UMR-IWW System Navigation Feasibility Study (USACE 2004) contains a comprehensive description of the environmental impacts of navigation traffic for existing traffic levels and modeled traffic levels for each decade to 2050.

In addition to the above National Environmental Policy Act documents, there currently exists an extensive literature describing the historic, current, and future geomorphic and ecological condition of the UMR, either including or specific to the MMR. The U.S. Geological Survey (USGS) conducted two (USGS 1999; Johnson and Hagerty 2008) ecological status and trends analyses of the UMR. The initial Status and Trends Report (USGS 1999) provided a thorough introduction to the UMRS including extensive descriptions of historical context, watershed geology and land use, floodplain forests, bird populations, water quality, fishes, aquatic vegetation and macroinvertebrates. The 1999 report (USGS 1999) provided the background information upon which the 2008 report (Johnson and Hagerty 2008) built. The 2008 Status and Trends Report focused on measuring changes in potential indicators of system health as derived from Long Term Resource Monitoring Program data. Twenty-four ecosystem indicators were chosen because they relate to many of the primary resource problems or outcomes important to managers. The 24 indicators were grouped into seven categories: hydrology, sedimentation, water quality, land cover, aquatic vegetation, invertebrates, and fish. Each indicator was evaluated for status across locations, including the MMR, and for trends over time, with estimates of uncertainty, when possible. The USGS also conducted a Habitat Needs Assessment for the UMR as part of Environmental Management Program (Theiling et al. 2000). The primary objectives of the Habitat Needs Assessment were the evaluation of existing conditions throughout the UMRS, forecasting future habitat conditions, and quantifying ecologically sustaining and socially desired future habitat conditions. Heitmeyer (2008) provided a detailed description of the historic physical and biological conditions specific to the MMR, changes to those conditions, and restoration and management recommendations.

Pursuant to 40 CFR 1502.21 and CEQ Guidelines, the above documents and analyses are incorporated by reference into this analysis for the purpose of reducing the size of this document and not duplicating applicable analyses. 40 CFR § 1502.21 requires that material incorporated by reference must be "reasonably available for inspection". The documents are available for review at:

http://www.mvs.usace.army.mil/Missions/Navigation/SEIS/Library.aspx

Physical Resources

River Stages

A summary of research on the effects of river training structures on flood heights is provided in Appendix A. As noted in the Environmental Consequences (Physical Resources, River Stages) section, 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 data show a trend of decreasing stages. It is not known if this is a result of construction of river training structures or the reduction of sediment load due to the construction of reservoirs on Mississippi River tributaries (Huizinga 2009). Reduced stages were acknowledged in the 1976 Regulating Works EIS (USACE) and the potential loss of side channels was discussed. The District acknowledges the importance of side channels and has continued to monitor the changes in the morphology and geometry of existing side channels. To offset potential impacts to side channels the District has initiated side channel restoration planning (USACE 1999a; Nestler et al. 2012) and has conducted a number of restoration projects. The number of side channels has been substantially preserved through these monitoring and restoration efforts combined with natural processes within the side channels.

Based on this analysis, the impacts of No Action and the Proposed Action, when evaluated in relation to past and present stage heights, are not anticipated to rise above what would occur naturally. The potential reduction in stages and impacts on side channels were addressed in the 1976 EIS. Potential impacts, if they are being caused by river training structures, should be offset by side channel restoration/enhancement features constructed in the future by the District under various authorities and the use of innovative river training structure configurations designed to divert flow into existing side channels.

Water Quality

Prior to the implementation of the Clean Water Act, the MMR was an open sewer and a convenient place to dump solid waste (Bi-State Development Agency 1954; U.S. Public Health Service 1958). Raw sewage, untreated industrial waste, and ground garbage were discharged into the MMR (in 1952, approximately 212 tons/day of garbage [animal and vegetable waste] were collected in St. Louis, ground, and discharged.) This resulted in high oxygen demand; extremely high fecal coliform levels; low dissolved oxygen levels (< 5 mg/l); transport of toilet paper, animal entrails, and other solid wastes; elimination of aquatic life below St. Louis and reduction of aquatic life for a large portion of the MMR; and unpalatable fish where they did exist (Ellis 1931; Ellis 1943; Platner 1943; Bi-State Development Agency 1954; U.S. Public Health Service 1958; Baldwin 1970). Severely degraded water quality conditions in the MMR rose to the level of a human health hazard and a conference was convened in St. Louis (U.S. Public Health Service 1958) to discuss remedies.

Water quality in the MMR has improved dramatically since the implementation of the Clean Water Act. Although the MMR has improved, it currently exceeds suggested nutrient (total nitrogen and phosphorus) guidelines either part of the time (nitrogen) or most of the time (phosphorous) (Johnson and Hagerty 2008). As discussed in the affected environment section, there are also fish consumption advisories for PCB, chlordane, and mercury contamination. During major storm events, raw sewage enters the river because of sewage treatment plant overloads due to combined (sewage/stormwater) sewage systems. Crites et al. (2012) found that water quality conditions in Buffalo Chute (River Mile 26) during isolation (mid-June through March during their study) from the river channel were not conducive to supporting healthy native fish communities. Thermal and chemical stratifications coupled with high water temperatures and anoxic conditions were observed during the summer months during two years of study.

Johnson and Hagerty (2008) indicated that future changes in nutrient inputs to the river are difficult to predict, and largely a function of outputs from sewage treatment plants and runoff from fertilizer application on land. There are ongoing efforts in the St. Louis area to improve wastewater treatment and alleviate the problems associated with combined sewage systems. These efforts should improve nutrient loading and eventually eliminate raw sewage overflow events. It is not anticipated that nutrients from agriculture will rise; however, this is driven by agricultural economics. The St. Louis District has conducted side channel restoration planning (USACE, 1999a; Nestler et al. 2012) and has been restoring side channels under various authorities. Water quality and aquatic ecosystem improvement are basic goals of these restoration efforts. So, water quality conditions in the MMR are expected to improve with time.

The No Action Alternative would have no additional impacts (existing level of dredging associated short-term turbidity plume) on water quality. The Proposed Action would have only minor, short-term construction impacts on water quality. Navigation traffic levels and associated turbidity pulses will remain the same under both the No Action and Proposed Action. As such, the impacts of No Action and the Proposed Action, when evaluated in relation to past, present, and future water quality impacts, are not anticipated to rise to the level of a significant impact.

Air Quality

The work area is currently designated as attainment areas for four of six criteria air pollutants (carbon monoxide, nitrogen oxides, sulfur dioxide, and lead) (USEPA 2013). The Missouri side of the Mosenthein/Ivory Landing Phase 5 work area is designated as a moderate nonattainment area for 8-hour ozone (1997 standard), a marginal nonattainment area for 8-hour ozone (2008 standard), and a moderate nonattainment area for particulate matter-2.5 (1997 standard) (USEPA 2013). On the Illinois side of the MMR, the work area is designated as a maintenance area for 8-hour ozone (1997 standard), a marginal nonattainment area for 8-hour ozone (2008 standard), and a moderate nonattainment area for particulate matter-2.5 (1997 standard) (USEPA 2013). There are no known foreseeable projects in the work area that would adversely impact air quality.

The No Action Alternative consisting of maintenance dredging would have minor impacts on air quality. The Proposed Action would have only minor, short-term, air quality impacts associated with the use of construction equipment. This construction activity would be represented by two pushboats and a barge-mounted crane. Navigation traffic levels and associated engine exhaust would remain the same under both the No Action and Action Alternatives. As such, the impacts of No Action and the Proposed Action, when evaluated in relation to past, present, and future air quality, are not anticipated to rise to the level of a significant impact.

Biological Resources (Fish & Wildlife)

Middle Mississippi River Floodplain

There are a number of competing theories on how river ecosystems operate (Johnson et al. 1995; McCain 2013). The flood pulse concept (Junk et al. 1989) is currently the most widely accepted theory for explaining the ecology of large floodplain rivers like the Mississippi River (Heiler et al. 1995; Gutreuter et al. 1999), but some aspects of large river ecosystems are not considered (Johnson et al. 1995). The flood pulse concept states that floodplain inundation is "the principle driving force responsible for existence, productivity, and interactions of the major biota in river-floodplain systems" (Junk et al. 1989). Regardless of inability of any single theory to completely explain the complex workings of large flood-plain rivers (Johnson et al. 1995; McCain 2013), one thing is clear, periodic inundation of the floodplain is extremely important and many organisms, both aquatic and terrestrial, are not only adapted to pulsed flooding, but require it.

A considerable number of scientific papers have been published describing the ecological importance of connectivity between the river and its floodplain for the Mississippi River and major tributary rivers. Periodic inundation (pulsed flooding) of the floodplain results in both sequestering and transport of nutrients (e.g., Schramm, Jr. et al. 2009); increased productivity of phytoplankton, zooplankton, and benthic invertebrates (e.g., Galat et al. 1998; Gosch et al. 2014); and spawning, feeding, and nursery areas for riverine fish (Barko et al. 2006). Floodplain inundation and connectivity with the river has been shown to be related to increased fish growth rates (Gutreuter et al. 1999; Schramm Jr. and Eggleton 2006; Jones and Noltie 2007; Phelps et al. 2014). Miranda (2005) found that the level of floodplain lake connectivity with the river plays an important role in structuring the fish fauna that is correlated with variables such as lake size, depth, distance from the river, and age. Annual floods homogenize the floodplain and provide connectivity to various degrees, allowing exchange of fish faunas between the river and floodplain that directly affect the fish species assemblages.

There are specific MMR examples of the importance of periodic flooding of the MMR for resident species. For example, the alligator gar (*Lepisosteus spatula*), a species extirpated from the MMR, historically used the floodplain during spring high water periods, most likely for spawning and rearing of young (Keevin and Lopinot 2015). The disconnection of the Mississippi River from its floodplain by agricultural levees may be partially responsible for the extirpation of this species in the northern portion of its range. The decurrent false aster (*Boltonia decurrens*), a Federally threatened plant species, life history is adapted to periodic inundation (Smith and Keevin 1998) and persistence of the species requires flooding to reduce competition (Smith et al. 1998).

Heitmeyer (2008) provides a detailed description of the historic physical and biological conditions of the MMR floodplain, changes to those conditions, and provides restoration and management recommendations. The MMR floodplain and river channel area encompass approximately 660,000 acres (Table 1), with approximately 202,000 acres (Table 2) of the river channel and the floodplain in the narrow strip of land between the river and the levees known as batture lands. The majority of the land in the floodplain can generally be categorized as rural and agrarian in nature. These areas are protected by an extensive levee and drainage system. Levees are prominent features and provide urban and agricultural flood protection for almost the entire length of the MMR, resulting in about 67% of foodplain area behind levees, while 33% of the land is outside of levee protection in the batture. In the MMR, almost all of the active (frequently flooded) floodplain is in the batture lands. The percentage of floodplain protected by levees is unlikely to change greatly because no new major realignment of levees is anticipated. However, there are currently on-going efforts to raise levees for urban flood protection. The establishment of the Middle Mississippi River Refuge (USFWS 2015) has resulted in re-establishment of floodplain connectivity in limited areas where levees were not repaired after the flood of 1993.

Currently, approximately 55% of the total floodplain is in agricultural production (Table 1), while 34% of the batture is in agriculture (Table 2). The only available land cover data for the time period around 1976 covers only the portion of the MMR that lay riverward of the levee (batture lands), limiting a comparison of changes between 1975 and 2000/2011 to the batture. Between 1975 and 2000/2011, agricultural land in the batture was reduced by 11.7% from 78,267 acres to 69,116 acres.

Forest is the second most abundant land cover class, currently occupying 17 percent of the total floodplain area (Figure 1) and approximately 26% of the batture lands (Table 2). Between 1975 and 2000/2011, forest cover increased by 2.1% in the batture. Area of floodplain forest declined in 24 of 31 reaches of the UMRS between 1989 and 2000 with a system-wide decrease of 5%, or 17,000 acres (Johnson and Hagerty 2008). In contrast, there was a slight increase of 1,200 acres (2%) in the MMR. The trend for floodplain forest is considered to be degrading in the impounded UMRS, but stable in the MMR.

Open water and developed lands currently occupy 11 and 9% of the total MMR floodplain, respectively. Between 1975 and 2000/2011 open water and developed land increased 2.1% and 6.7%, respectively within the batture. The remaining three categories, grass/forbs, marsh, and sand/mud, each currently account for less than 4 percent of the floodplain. Between 1975 and 2000/2011, marsh increased 300 acres (4.4%), grass/forbes area increased 2492 acres (183 %), and sand/mud decreased 68 acres (1.2%), within the batture.

Table 1. MMR floodplain land cover categories, acreages, and percentages (based on Upper Mississippi River Restoration - Environmental Management Program Long Term Resource Monitoring Program data; USGS 2014).

Land Cover Category	**2000/2011 Acreage* (% of Total)**
Agriculture	364,216 (54.8%)
Forest	114,263 (17.2%)
Open Water	73,137 (11.0%)
Developed	61,197 (9.2%)
Grass/Forbs	23,079 (3.5%)
Marsh	22,944 (3.5%)
Sand/Mud	5,965 (0.9%)
No Coverage	N/A
Total	664,801

*Parts of the Project Area were not covered by the 2011 dataset, requiring the addition of 2000 data.

Table 2. MMR land cover categories, acreages, and percentages of the narrow strip of land between the river and levees known as batture lands (based on Upper Mississippi River Restoration - Environmental Management Program Long Term Resource Monitoring Program data; USGS 2014).

	1975 Acreage (% of Total)	**2000/2011 Acreage* (% of Total)**
Agriculture	78,267 (38.8%)	69,116 (34.3%)
Open Water	58,599 (29.0%)	59,844 (29.7%)
Forest	47,321 (23.5%)	52,110 (25.8%)
Developed	3,744 (1.9%)	3,995 (2.0%)
Marsh	6,861 (3.4%)	7,161 (3.5%)
Sand/Mud	5,573 (2.8%)	5,641 (2.8%)
Grass/Forbs	1,360 (0.7%)	3,852 (1.9%)
Total	201,725	201,725

*Parts of the Project Area were not covered by the 2011 dataset, requiring the addition of 2000 data.

The U.S. Fish and Wildlife Service established the Middle Mississippi River National Wildlife Refuge on May 31, 2000 (USFWS 2015). The refuge lands were purchased in response to the flood of 1993. The refuge currently consists of seven divisions that total nearly 7,000 acres (Meissner Island Division, River Mile (RM) 153.5–155.5L – 78 acres; Harlow Island Division, RM 140.5-144R - 1,255 acres; Beaver Island Division, RM 116-118R - 245 acres; Horse Island Division, RM 111-112R - 2,110 acres; Rockwood Island Division RM 99-104L – 722 acres; Crain Island Division, RM 104-107 – 553 acres; Wilkinson Island Division, RM 88.5-93L - 2,532 acres) spread out along the MMR. Much of the refuge land had previously been cut off from the floodplain by private levees protecting agricultural land. Most of the levees were breached by the 1993 flood and have not been repaired. The refuge now provides access to the floodplain for native fish during high water stages and creates a corridor of floodplain forest habitat for migratory birds and resident wildlife. The refuge was designated as an important Bird Area in 2008.

Frequent flooding occurs on refuge tracts due to their position in the river floodplain. Modifications to man-made structures such as levees promote healthy and diverse fish habitat for native Mississippi River fishes. Where possible, old river channels and swales on refuge lands will be managed with passive water control structures to provide for seasonal wetlands for migratory birds. By allowing these lands to flood and re-connect with the river, the refuge contributes to the overall health of the ecosystem. Former agricultural lands are being allowed to return to forested habitat, with the occasional tree plantings to promote species diversity and abundant food for native wildlife. Many species of fish and wildlife should benefit from the habitat restoration, and the public will have increased opportunities for wildlife-dependent outdoor recreation.

Under both the No Action Alternative and the Action Alternative, the future condition of the floodplain is, for the most part, independent of the 9-foot Navigation Project in the MMR. The impacts of No Action and the Proposed Action, when evaluated in relation to past, present, and future condition of the MMR floodplain, are not anticipated to rise to the level of being significant. The floodplain has historically been isolated from the river and important biological functions that are dependent on riverine connectivity have been lost for most of the MMR floodplain. It is anticipated that the MMR levee system will be improved and maintained to meet current federal standards for urban flood protection. Agricultural levees will also be maintained to meet federal standards for agricultural flood protection and repaired under the PL 84-99 program, if levee districts are in the program, meet federal requirements, and request federal assistance. Development on the floodplain (i.e., housing development, industry, roads, etc.) is totally independent of the Regulating Works Project. The isolation and protection of the floodplain was a societal decision and can only be changed by Congressional action or private sector investment (i.e., private sector entities, other than the agricultural sector, purchasing the land and reconnecting the river to the floodplain for fish and wildlife purposes). This has happened to a minor degree with the establishment of the Middle Mississippi River Refuge. However, there are no known plans by environmental groups or individuals to purchase large segments of the floodplain for fish and wildlife purposes.

It is possible that in the future navigation related development (i.e., port development, loading/unloading facility development, operation and maintenance of existing facilities, etc.) may occur. A comprehensive economic analysis to determine potential future navigation related facility needs has not been conducted. However, it is anticipated that development would occur adjacent to existing facilities where infrastructure is already in place. The St. Louis District has concluded that the construction of training structures in the MMR does not affect water surface elevations at higher flows. Based on the Corps' analyses, training structure construction activities will not result in increased flood risks to the MMR floodplain.

Dike & Revetments (Dikes, Bendway Weirs, and Revetment)

Currently, there are approximately 1,375 river training structures on the MMR, which include wing dikes, bendway weirs, chevrons, and other configurations. Of this total, 175 are bendway weirs. The pace of construction has changed over time and the shape, size, elevation and configuration of river training structures has also changed. The St. Louis District built approximately 450 river training structures in the late 19th century and another 250 in the 1930s. The District constructed 150 bendway weirs from 1990 to 2000. The proposed work area is between River Mile (RM) 160 and 162.5. Krischell et al. (2014) did a comprehensive survey of dikes in a nine mile stretch of the Mississippi River, between RM 165.00 and RM 156.00, that encompasses the work area. There are a total of 66 river training structures including dikes, chevrons, and weirs as well as revetment within the nine mile reach that includes the 2.5 mile work area. Table 3 of the Krischell et al. (2014) report provides the location of the structure, date of construction, date of major modifications, constructed length, and current condition. Table 3 below lists work areas that are considered likely to be constructed in the reasonably foreseeable future.

The St. Louis District has one Regulating Works HSR model study that is almost complete and will likely result in future construction: the Upper Brown's Bar HSR Model Study. The Upper Brown's Bar HSR Model Study is a river engineering design that will reduce or eliminate the need for repetitive dredging at approximately UMR 24. The Red Rock Landing Report will be completed in FY 16 and construction is projected for FY 18. Success of the Regulating Works Project is dependent on careful evaluation of conditions on the Middle Mississippi River over time while incrementally implementing river training structures to provide a safe and dependable navigation channel while reducing the need for repetitive dredging. Future needs are based on priority work locations that are determined by examining repetitive dredging problems on the Middle Mississippi River. The District then develops alternatives using widely recognized and accepted river engineering guidance and practice, and then screens and analyzes different configurations of regulating works with the assistance of a Hydraulic Sediment Response (HSR) model. During the alternative evaluation process, the District works closely with industry and natural resource agency partners to further evaluate potential alternatives, including configurations analyzed in the HSR model. This process results in alternatives which reasonably meet the project purpose while also avoiding/minimizing environmental impacts. The timing of future construction is heavily dependent on Congressional funding and modeling results.

Table 3. List of Regulating Works work areas showing location and structure type that are under construction or considered likely to be constructed in the reasonably foreseeable future (USACE 2012a; USACE 2012b; USACE 2013a; USACE 2013b).

Major Reach	Status	Localized Reach	Work in Reach
Mosenthein-Ivory Landing Phase 4 (RM 195-154)	Contract Awarded	St. Louis Harbor	Revetment RM (175-171) Dike 173.4L
Eliza Point/Greenfield Bend Phase 3 (RM 20 - 0)	Under Construction	Bird's Point (RM 4 - 0)	Rootless Dike 3.0L Revetment RM 3.0L Weir 2.6R Weir 2.5R Weir 2.3R Weir 2.2R
	Construction in FY 16	Boston Bar (RM 10.3 – 7.0) Biological Opinion Program	Dike 10.30L Remove Dike Dike 10.10L Notch Pile Dike Dike 10.10L Remove Dike Dike 10.05L Side Channel Enhancement Dike Dike 7.90L Remove Dike
Grand Tower Phase 5 (RM 90 - 67)	Construction in FY 16	Crawford Towhead (RM 75 - 71)	Chevron 73.6L Dike Extension 72.9L Chevron 72.5L
		Vancil Towhead (RM 70-66)	Weir 69.15L Weir 68.95L Weir 68.75L Diverter Dike 68.10L Diverter Dike 67.80L Diverter Dike 67.50L Repair Dike 67.80L Shorten Dike 67.30L Shorten Dike 67.10L 600 ft revetment
Dogtooth Bend Phase 5 (RM 40-20)	Under Construction	Bumgard (RM 33-27)	Weir 34.20L Weir 34.10L Weir 32.50L Weir 32.40L Weir 32.30L Weir 32.20L Dike 31.60R Weir 30.80R Weir 30.70R
Mosenthein _Ivory Landing Phase 5	Construction in FY 15	Mouth of the Meramec (RM 160-162.5)	Weir 162.30R Weir 162.20R Weir 162.10R Weir 162.00R Rootless Dike 161.70L Rootless Dike 161.50L Rootless Dike 161.10L
Dogtooth Bend Phase 6 (Upper Brown's Bar)	Construction in FY17	Upper Brown's Bar (RM 23-26)	Weir 25.70L Weir 25.60L Weir 25.40L

Major Reach	Status	Localized Reach	Work in Reach
			Weir 25.20L Dike Extension 24.40L Dike Extension 24.30L Dike Extension 24.20L Offset Rootless Extension 25.30R Offset Rootless Extension 24.80R Offset Rootless Extension 24.70R Notch Closure 24.80R Partial Removal 24.70R Dike 24.75R
Red Rock Landing	Construction in FY 18	Red Rock Landing (RM 96-104)	To Be Determined

A discussion of the environmental impacts of dikes and weirs is contained in Section 4 Environmental Consequences (**Physical Resources**: River Stages and **Biological Resources**: Dike Effects and Weir Effects). Potential cumulative impacts of the Regulating Works Project on biological resources fall into a number of general categories: 1. Biological effects of training structures and their construction, and the biological implications of existing and reduced dredging; 2. Potential impacts of reduced channel migration; and, 3. Potential effects of changed flow patterns.

1. Construction impacts (actual construction related impacts) would be minimal under the no action alternative because no new construction (no construction impacts) would occur and structure repair would have minimal impacts. Under the no action alternative, dredging frequency, quantity, and area dredged would remain similar to what it is today. Benthic invertebrates in the dredged area would be killed and dredged material disposal would cover and kill benthic invertebrates in the disposal area. These areas would recover at a rate that is most likely site specific, but the cycle would continue the next time dredging is required (Koel and Stevenson 2002).

   Under the action alternative, benthic invertebrates in any future construction areas would be covered by the structure (rock) and killed. The area under the structures would be covered and unavailable for future colonization by benthic invertebrates. The environmental effects of training structures have been described in detail in Section 4 – Environmental Consequences. Although the benthic fauna type will change, rock is far more attractive to benthic invertebrates than shifting sand and the density (numbers/meter) will increase dramatically. This increase in benthic invertebrate density will also be more attractive to fish species. Construction of dikes has been suggested as a method for ecological enhancement (Radspinner et al. 2010) of river ecosystems. The St. Louis District has worked with partner agencies to develop innovative training structure configurations that fully serve their intended navigation function while providing environmental benefits at the same time. The structures themselves directly create/enhance aquatic habitat and provide fishery benefits. For example, chevron dike construction in St. Louis Harbor provided increased habitat diversity and increased fish use (Schneider 2012); off-bank dike notching has been used for island creation (River

Mile 100 Islands) which has benefited the fishery (Allen 2010); wing dikes provide adult (Barko et al. 2004) and larval fish (Niles and Hartman 2009) habitat, wing dike tips provide summer habitats for juvenile rheophilic fishes (Bischoff and Wolter 2001) and dike scour holes provide fish habitat, especially during the winter. Under the action alternative, future dredging and associated impacts to the benthic fauna would be reduced in frequency and quantity.

Following a period of widening and instability on the MMR, historic dike construction caused a narrowing of the river planform due to sediment accretion followed by terrestrial vegetation growth (Brauer et al. 2005; Brauer et al. 2013). Continued operation and maintenance of the training structures has maintained the narrowed channel. Figure 6 in the EA shows the average planform width of the MMR from 1817 through 2011. Since 1968, the channel width appears to have reached a dynamic equilibrium with very little change occurring. It is anticipated that dynamic equilibrium in channel width will be maintained with little change resulting from additional training structure construction. As such, the impacts of No Action and the Proposed Action, when evaluated in relation to past, present, and future biological impacts of structure construction and operation and maintenance of the structures, are not anticipated to rise to the level of a significant impact.

2. As noted in Cumulative Impact Analysis (Side Channels), the potential for the natural development of new MMR side channels, which is a natural geomorphic process in fluvial river systems (Grenfell et al., 2012), has been restricted by the placement of stone revetment on the bankline as part of the Regulating Works Project. Bankline revetment restricts channel migration and has fixed the MMR in place, thus eliminating the potential for new natural side channel development. Since no new natural side channels are being created, it is essential to engineer new side channels through the manipulation of existing river training structures and new innovative river training structure configurations as well as maintain and restore those that remain through other programs authorized to so. Based on the analysis conducted in the Side Channel Section, the impacts of No Action and the Proposed Action, when evaluated in relation to past, present, and future condition of MMR side channels, are not anticipated to rise beyond the levels previously described in the 1976 EIS.

3. Dikes change flow patterns and increase both velocity and turbulence near the structure (Yossef and de Vriend 2011; Jia et al. 2009; and Ouillon and Dartus 1997 and others). McElroy et al. (2012) have recently found that fish use particular paths for migrations that take advantage of flow velocities (both high and low velocities) to reduce their energy output during migrations. Currently, the extent of this potential impact in the MMR is unknown, and the means to obtain a full understanding of how this information may or may not impact the MMR is not known as this would be scientifically difficult to evaluate. The Corps continues to apprise, analyze, and consider any research or potential issues with respect to the impact of changing flow patterns on fish and wildlife.

Navigation Traffic

The movement of commercial navigation traffic has both physical and biological effects (Table 4) that affect the ecosystem health of the MMR. These impacts are discussed in greater detail in USACE (2004) and Söhngen et al. (2008). With respect to cumulative impacts (past, present, and future actions), the impacts of commercial navigation traffic resulted from the original development of the navigation project and subsequent operation and maintenance of the navigation channel. Because none of the actions associated with operation and maintenance will increase traffic and associated impacts, the impacts of the No Action Alternative and the Action Alternative are identical. In other words, only an action (construction project) that would increase traffic would also increase impacts beyond what we have today.

Although, there are many potential impacts associated with the movement of towboats through the system as described in USACE (2004) and Söhngen et al. (2008) and summarized in Table 4, the impact of greatest concern in the MMR is larval and adult fish mortality associated with towboat propeller entrainment.

Existing (2000) traffic in the Middle Mississippi River was responsible for the annual equivalent adult mortality of 262,853 fish, based on the number of larval fish killed passing through towboat propellers (USACE 2004, page 91). Annual equivalent adult mortality resulting from the incremental increase in traffic due to the construction of 1,200 foot locks on the Upper Mississippi River (USACE 2004 – a project not funded for construction) was projected to be between 11,612 and 79,274 fishes in the Middle Mississippi River for the year 2040 (USACE 2004, 396-397).

Killgore et al. (2011) published a towboat propeller entrainment paper for adult fish for the pooled portion of the Upper Mississippi River. It indicated that fish entrainment was low (< 1 fish/km) in wide, deep and fast sections of the river, while it was variable and occasionally high (> 30 fish/km) in narrow, shallow, and slow reaches of the UMR. If you used the value of 1 fish/km injured or killed (the MMR is wide, deep and fast), then approximately 151,161 fish would be injured or killed per year (313.822 km x 19,938 towboats/year x .024 injury-mortality rate) in the Middle Mississippi River under existing traffic conditions. This number overestimates mortality, because only a fraction of towboats/year actually navigate the entire length of the system (only 7,750 locked through Locks 27).

Additionally, another 34,972 adult fish are killed per year locking through Locks 27 (4.5125 average fish mortality per lockage x 7,750 commercial lockages in 2001) (Keevin et al. 2005). Entrainment mortality of some fish species, for example the shovelnose sturgeon, combined with other mortality factors (commercial fishing) may be responsible for unsustainable population levels in the Upper Mississippi River (Miranda and Killgore 2013).

Table 4. Potential Aquatic Impacts Associated with the Movement of Tows on the Middle Mississippi River

Impact	**Reference**
Fish Recruitment	(Nielsen et al. 1986; Arlinghaus et al. 2002; Huckstorf et al. 2010)
Propeller Mortality	
Adult Fish	(Gutreuter et al. 2003; Killgore et al. 2005; Killgore, et al. 2011; Miranda & Killgore 2013)
Adult Fish during Lockage	(Keevin et al. 2005)
Larval Fish	(Holland and Sylvester 1983; Holland 1987; Odum et al, 1992; Killgore et al. 2001; Bartell & Campbell 2000)
Fish Disturbance (Displacement from Channel)	(Todd et al. 1989; Wolter and Bischoff 2001; Gutreuter et al. 2006)
Wave Wash	
Physical	(Bhowmik et al 1999)
Fish	(Sheehan et al. 2000a, 2000b; Wolter & Arlinghaus 2003; Wolter et al. 2005; Kucera-Hirzinger et al. 2009; Gabel et al. 2011b)
Invertebrate	(Bishop & Chapman 2004; Gabel et al. 2008; Gabel et al. 2011a, 2011b)
Shoreline Drawdown/Dewatering	(Adams et al 1999; Maynord 2004; Maynord & Keevin 2005)
Towboat Induced Turbidity	
Channel	(Smart et al. 1985; Savino et al. 1994; Garcia et al. 1999; In addition, there are numerous publications on the adverse effects of turbidity on benthic invertebrates and fish.)
Phytoplankton	(Munawar et al. 1991)
Side Channel/Backwaters	(Pokrefke et al. 2003)
Hull Sheer	
Larval Fish	(Morgan II, et al. 1976; Maynord 2000; Keevin et al. 2002)
Turbulence	(Killgore et al. 1987; Mazumder et al. 1993; Deng et al. 2005)
Towboat Dispersal of Exotic Species	(Keevin et al. 1992)
Towboat Noise & Fish Disturbance	(Wysocki et al. 2006)
Bank Erosion	(Bhowmik et al. 1999; Nanson et al. 1993)
Risk of Accidents & Hazardous Spills	(University of Memphis 1998; Marmorstein 2000)
Changed Velocities	(Maynord 2000; Sheehan et al. 2000a; Sheehan et al. 2000b

In addition to the above projected mortality numbers, an unknown number of fish would be killed due to egg mortality from propeller entrainment (Holland and Sylvester 1983; Odum et al, 1992), shoreline dewatering (Adams et al 1999; Maynord & Keevin 2005), hull shear (Morgan II, et al. 1976; Maynord 2000; Keevin et al. 2002), and fish being washed out of protected areas (especially during the winter) due to wave wash (Sheehan et al. 2000a, 2000b; Wolter and Arlinghaus 2003; Wolter et al. 2005; Kucera-Hirzinger et al. 2009).

Based on this analysis, the impacts of No Action and the Proposed Action (no increases in navigation traffic), when evaluated in relation to past, present, and future impacts associated with the movement of navigation traffic, are not anticipated to rise beyond the existing conditions and projected traffic increases which have been addressed in USACE (2004).

Side Channels

With the draining of floodplain lakes for agricultural development and the reduction of overbank flooding during high flows due to levee construction, side channels represent the major source of off-channel water bodies on the MMR. Secondary channels typically provide a well-defined gradient between flowing to non-flowing water depending on their level of connectivity to the main channel. Based on the level of water flow, secondary channels can function as wetlands, isolated backwaters, connected backwaters, isolated secondary channels (at low stages), and flowing secondary channels. Level of connectivity also affects substrates, water quality conditions (Crites et al. 2012), benthic invertebrate communities (Bij de Vaate et al. 2007; Paillex et al. 2009) and fish faunas (Barko and Herzog 2003; Barko et al. 2004). Flowing secondary channels, those connected to the main channel, generally have course bottom substrates (i.e., sand and gravel) and support large river aquatic species (suckers, minnows, and darters) tolerant of current and/or turbidity. Disconnected secondary channels generally have finer substrate types (sand and silt) and support lentic species that prefer moderate to low current and low turbidity levels (Barko and Herzog 2003). This diversity of habitat provides important feeding, spawning, nursery, and overwintering habitat for fish (Lowery et al. 1987; Scheaffer and Nickum 1986; Grift et al. 2001), and habitat for other environmentally sensitive invertebrates, fish, and wildlife (Eckblad et al. 1984; Siegrest and Cobb 1987; Barko and Herzog 2003). Secondary channels also export nutrients, detritus, plankton, invertebrates, and fish to the main channel and the Gulf of Mexico (Eckblad et al. 1984; Cellot 1996; Simons et al. 2001; Hein et al. 2004; Preiner et al. 2008).

Secondary channels are also important because they are a refuge for fish escaping navigation related disturbances. Galat and Zweimuller (2001) and Wolter and Bischoff (2001) hypothesized that commercial navigation traffic may push fish toward the littoral zone or into secondary channels. Gutreuter et al. (2006) estimated the magnitude of traffic-induced reduction of fishes in the main channel of the Upper Mississippi River by comparing fish abundance in the navigation channel relative to abundance in secondary channels. They found the presence of some species was unaffected by traffic disturbances; whereas, the presence of others was reduced. Thus, secondary channels contribute to the overall health of the riverine system (Baker et al. 1991; Simons et al. 2001).

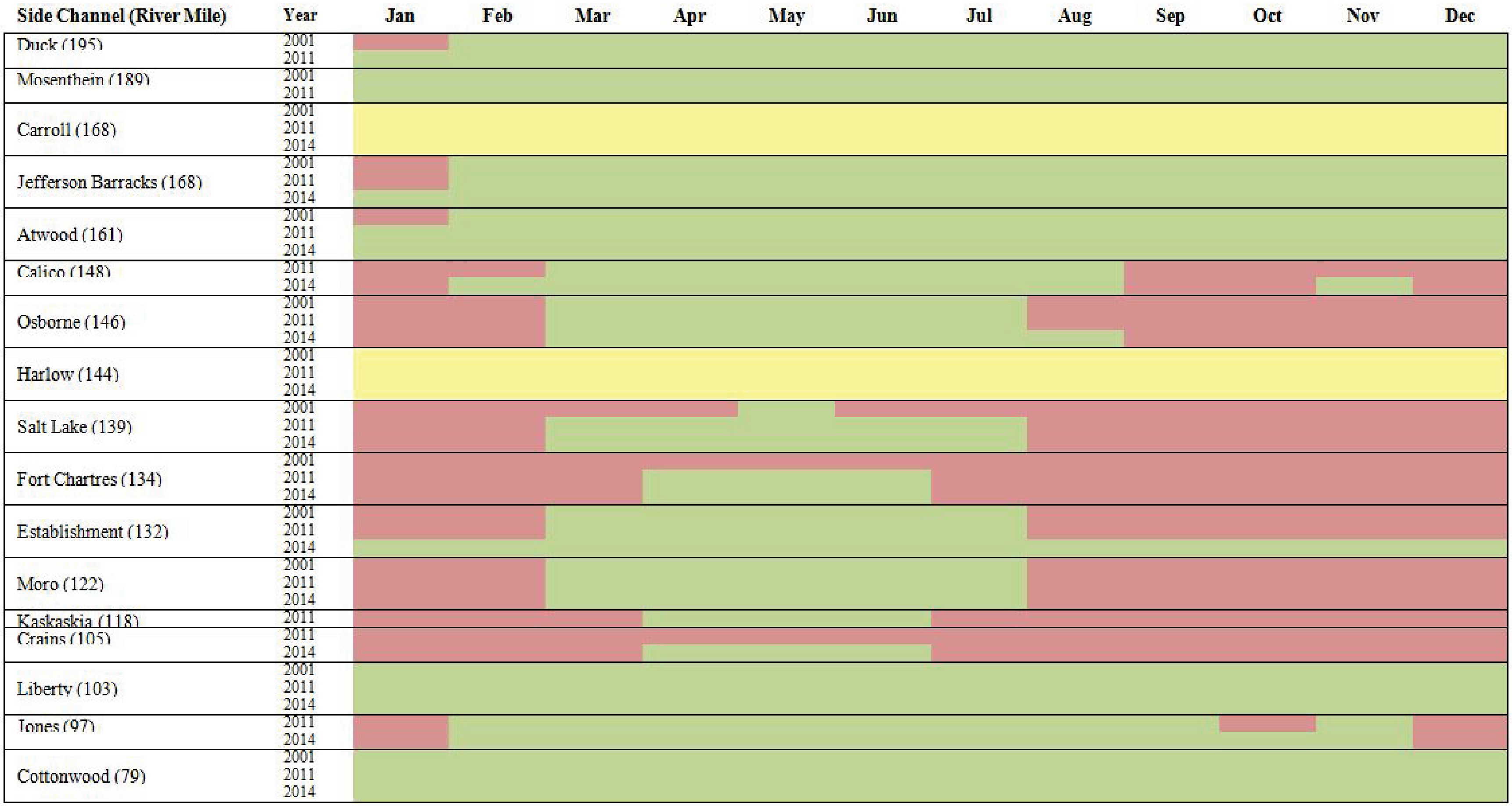
Due to the placement of rock closing structures, almost all MMR side channels are isolated from the main channel based on river stages and the crown elevation of the closing structure. The purpose of closing structures is to shunt water to the main channel to support navigation flows. Of the extant thirty-two side channels, only one (Cottonwood Side Channel) does not have closing structures. The remaining MMR side-channels are in various successional stages, including wetlands, isolated backwater, connected backwaters, isolated side channels (at low stages), and flowing side channels. The successional stage is related to ground elevation and river discharge, which translate into the level of connectivity to the main channel. The current median level of MMR side channel connectivity on a monthly basis for the years 2001, 2011, and 2014 is shown in Table 5. Note that the level of connectivity has remained relatively stable or increased slightly in 2014**.**

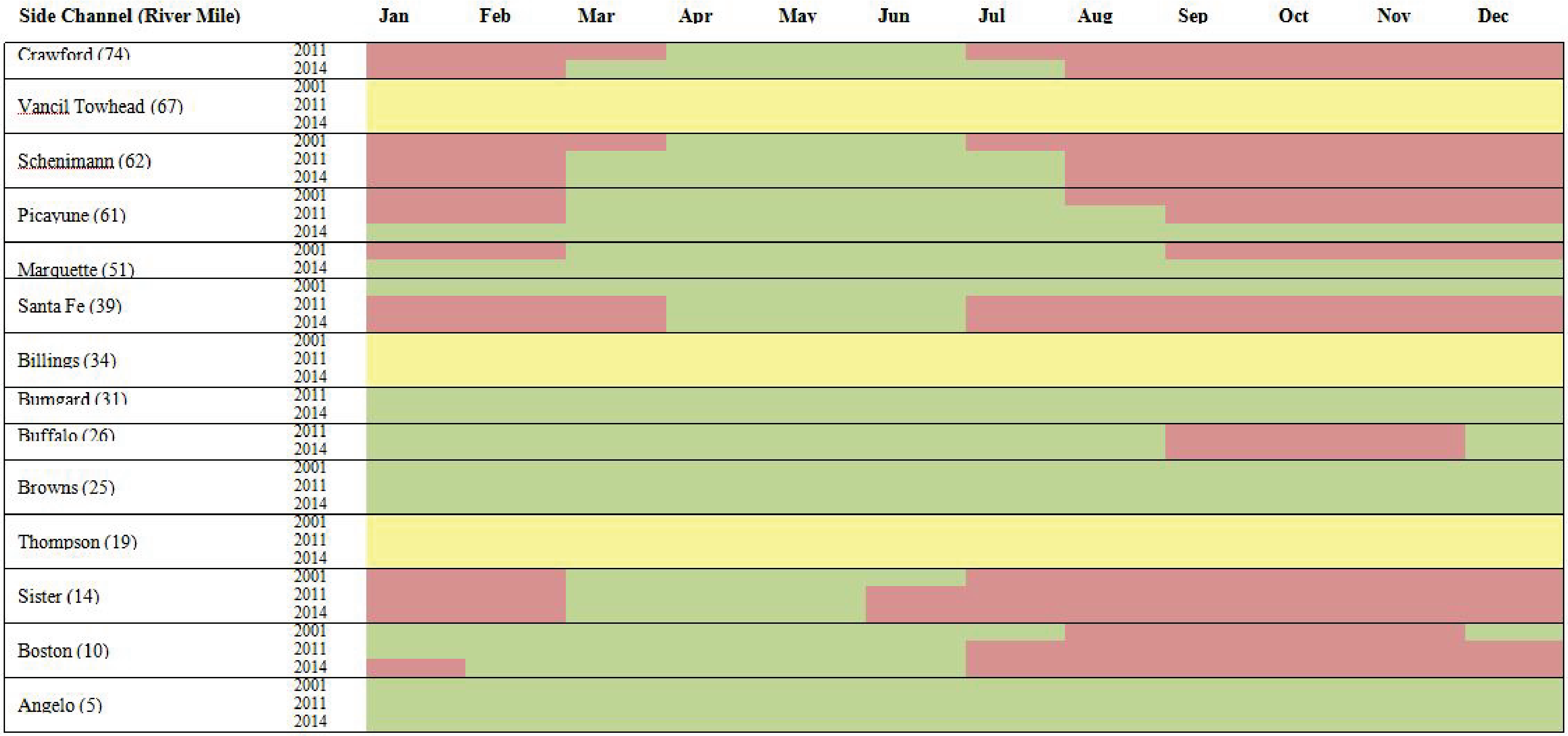
The 1976 MMR Regulating Works EIS indicated that most of the side channels would be lost "Based on Colorado State University studies of man-induced changes in the Middle Mississippi River, most of the side channel and main channel border habitat will eventually become filled with sediment (Simons, Schumm, and Stevens, 1974), unless artificial means, i.e., dredging, are employed to maintain side channels (page 216)." This is supported to some extent by the findings of Theiling et al. (2000) who examined land cover evolution at six side channel study sites using geographic information system (GIS) coverages derived from aerial photographs taken in 1950 or 52, 1975, 1989, and 1994. The study found that the six MMR side channels evaluated were showing trends toward filling with sediment. Contrary to these conclusions, an analysis of MMR geomorphology by Brauer (2013) found that, similar to main channel widths, side channel widths have reached a dynamic equilibrium and remained relatively steady since 1968. These trends were found both in average trends and reach scale trends. These trends were also found in Guntren (2011). This study found that while some side channels decreased over the course of the study, others were increasing, suggesting that side channels in the MMR are dynamic.

Side channel bathymetry is dynamic and changes with flood events which scour some areas and redeposit sediments in other areas. In an ongoing study of side channels being conducted by the St. Louis District, it has been found that the total water volume of MMR side channels has been increasing over the past 15 years (See Figure 1).

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.

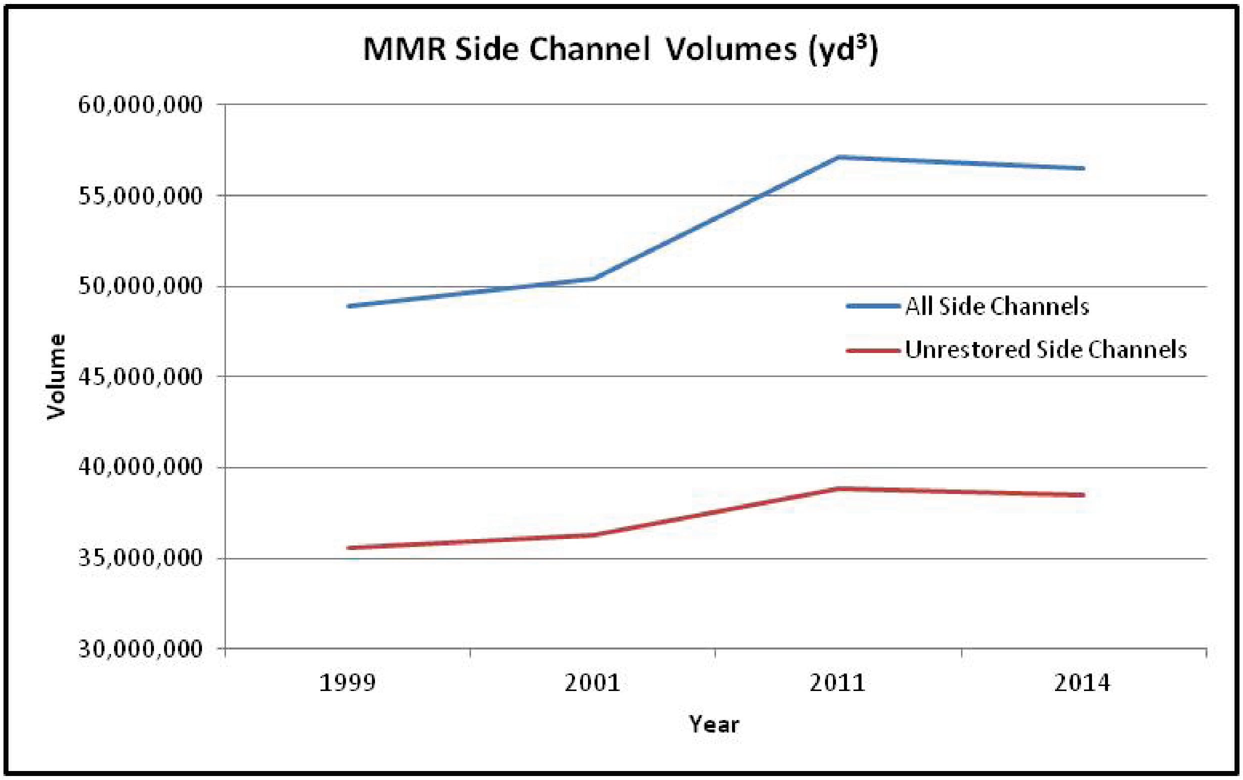
Table 5: A visual representation of flow conditions for Middle Mississippi River side channels showing months when channels are connected to the river and flowing (green) and when they are not flowing (red) based on median monthly stages and 2001, 2011, and 2014 bathymetric data. Yellow represents side channels with high barriers restricting flow during all but extremely high water events.





Side Channel (River Mile)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Crawford (74) 2011 2014
Vancil Towhead (67) 2001 2011 2014
Schenimann (62) 2001 2011 2014
Picayune (61) 2001 2011 2014
Marquette (51) 2001 2014
Santa Fe (39) 2001 2011 2014
Billings (34) 2001 2011 2014
Bumgard (31) 2011 2014
Buffalo (26) 2011 2014
Browns (25) 2001 2011 2014
Thompson (19) 2001 2011 2014
Sister (14) 2001 2011 2014
Boston (10) 2001 2011 2014
Angelo (5) 2001 2011 2014

Figure 1. Total volume in cubic yards of all MMR side channels for which data were available and for those unrestored MMR side channels for which data were available.



The potential for the natural development of new MMR side channels, which is a natural geomorphic process in fluvial river systems (Grenfell et al., 2012), has been restricted by the placement of stone revetment on the bankline as part of the navigation system's Regulating Works Project. Bankline revetment restricts channel migration and has fixed the MMR in place, thus eliminating the potential for new natural side channel development. Since no new natural side channels are being created, it is essential to engineer new side channels as well as maintain and restore those that remain.

The reduced potential for the natural formation of new side channels and the current degree of connectivity to the main channel is the existing condition. Any future construction of bankline revetment will not impact the potential for major channel migration and the creation of a new side channel complex. There are no plans to build new closing structures on any side channels. The St. Louis District understands the biological importance of side channels and has conducted environmental planning, in coordination with our agency partners, for side channel restoration in the MMR (USACE, 1999a; Nestler et al., 2012). A number of side channel projects have been completed to improve flow and create more diverse aquatic habitat (i.e., environmental dredging of Sister Chute to provide more open water; environmental engineering to create/restore habitat in Santa Fe Chute, Marquette Chute, Jones Chute, and Establishment Chute) under a variety of authorities outside of the Regulating Works Project. It is anticipated that more side channel restoration will occur in the future as discussed above.

Based on this analysis, the impacts of No Action and the Proposed Action, when evaluated in relation to past, present, and future condition of MMR side channels, are not anticipated to rise to the level of being significant.

Threatened and Endangered Species

Section 7 consultation, under the Endangered Species Act, and compliance with the Act has a very structured coordination process between an action agency (the St. Louis District for this work area) and the U.S. Fish and Wildlife Service. In 1999, a Biological Assessment was prepared for the operation and maintenance of the 9-foot navigation project on the Upper Mississippi River (USACE 1999b). The U.S. Fish & Wildlife Service prepared a Biological Opinion in response to the BA (USFWS 2000). The Service made a jeopardy determination for a number of species and provided Reasonable and Prudent Alternatives to avoid jeopardy. The Service also prepared an Incidental Take Statement and provided Reasonable and Prudent Measures for a number of species. The Biological Opinion assessed the impacts of past and on-going operation and maintenance activities. An agreement was made that Tier II Biological Assessments would be prepared to address potential future site specific impacts of construction projects related to the operation and maintenance of the navigation project. This coordination and compliance process has been followed since 2000.

Recently, four Biological Assessments were prepared for construction of regulating works (USACE 2012a; USACE 2012b; USACE 2013a; USACE 2013b) on the MMR. For these work areas, the U.S. Fish and Wildlife Service conducted a Tier II Formal Consultation. The Service determined that the work falls within the scope of the programmatic BO issued for Operation and Maintenance of the 9-Foot Navigation Channel on the Upper Mississippi River System and that incidental take was considered programmatically in the BO. As such no new incidental take statement was included with the opinions. It was the Service's biological opinion that the Proposed Actions are not likely to jeopardize the continued existence of the pallid sturgeon.

The impacts of the Proposed Actions, when considered in relation to the past and present (2000 study evaluation baseline) did not rise to the level that any of the species being evaluated would be jeopardized or that the existing incidental take criteria were exceeded. In addition, the St. Louis District has implemented a number of projects under a variety of authorities to benefit the pallid sturgeon (e.g., placement of large woody structures; incorporation of woody debris into dikes; environmental dredging of Sister Chute; environmental engineering to create/restore habitat in Santa Fe Chute, Marquette Chute, Jones Chute, and Establishment Chute; dike modification to create habitat; design and utilization of innovative dike configurations to create habitat diversity; testing of flexible dredge pipe for future habitat creation; etc.) and least tern (e.g., modification of island tip at Ellis Island to create nesting habitat; creation of nesting habitat on floating barges; sandbar isolation from shoreline in the MMR to provide nesting habitat) These types of restoration/rehabilitation/enhancement projects will continue into the future to benefit threatened and endangered species in the MMR.

Climate Change

A cumulative impact assessment of the impact of climate changes on the MMR is highly speculative because the projected trends are so general and can be offsetting predictions (one area receives more rain while another receives less). Should climate change result in more frequent and more severe storms, then there is a potential for more sediment input into the system which "might" result in more dredging (under the No Action Alternative and the Proposed Action), depending on the level of increase. The Proposed Action should offset some of the need for additional dredging in the existing repetitive dredging area, but the nature and extent of future dredging requirements under different climate change scenarios is nearly impossible to predict. If flow levels rise, there is a possibility that the side channels would be connected to the main channel more often (under both the No Action and Action Alternatives), depending on the level and duration of stage increase. Although highly speculative based on the existing data, the past, present, and future impacts of both the no action and the Proposed Action, are not anticipated to rise to the level of being significant.

Socioeconomic Resources

The Mississippi River is essential to the economies of the counties and states that border it. The people living and working in those places rely on the river system for their livelihood. Water transportation supports thousands of jobs throughout the river corridor, and the Nation, in a variety of industries. Agricultural, mining, and manufacturing industries; public utilities; waterside commercial development; and water-based recreational activities depend on the inland waterway for their livelihood. The Regional Economic Development study conducted as part of the Upper Mississippi River-Illinois Waterway System Navigation Feasibility Study (USACE 2004) traced expenditures and transportation cost savings throughout the economy in terms of additional full-time employment, wage and salary income, and output of the value of the goods produced. The analysis reported that within the study area States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin, 21,891 man-years of employment are generated by water based industries. This benefit also has an impact on other regions as well as the entire United States. In the states bordering the study area, income generated by these business activities was estimated to be over $509 million, and for the entire United States it was estimated to be over $1.2 billion. Inland water transportation generates thousands of jobs and millions of dollars in taxes for State and Federal governments.

The Middle Mississippi River Regulating Works Project is an integral part of the inland water transportation system. The long-term goal of the Project, as authorized by Congress, is to provide a sustainable and safe navigation channel and reduce federal expenditures by alleviating the amount of annual maintenance dredging and the occurrence of vessel accidents through the construction of regulating works. Past Regulating Works Project actions have been successful in providing a sustainable and safe navigation channel, reducing vessel accidents, and reducing the average annual dredging requirements in the MMR. Present and reasonably foreseeable future actions are expected to continue this trend.

Historic and Cultural Resources

Historic and cultural resources within and in proximity to the Middle Mississippi River have been, and continue to be, subjected to natural riverine processes (e.g., bankline and riverbed erosion). Anthropogenic changes to the system have also impacted those resources since at least the 18th century. As Euro-American settlements developed along the river, levee systems began to be constructed by landowners and communities for flood control. Beginning in the mid-19th century, structures were constructed in the river to modify water-flow to either decrease or increase sedimentation in specific locations. Dikes, for example, directed the water current to eliminate sandbars, and hurdles were used to close off chutes between towheads and riverbanks causing them to fill with sediment, and effectively narrow the river. While specific cultural resources might be adversely impacted by increased waterflow and resulting erosion, others were protected by increased sedimentation. In 1879 the Mississippi River Commission (MRC) was created by Congress to promote commerce and prevent flooding. Part of the MRC mission was to permanently locate and deepen the navigation channel and stabilize river banks. The construction of dikes and embankments has greatly reduced bankline erosion and halted river migration, thereby protecting cultural resources, both known and unknown, from destruction.

All construction and modification work on dikes and weirs is carried out using barges, without recourse to land access; therefore, any potential effects are limited to submerged cultural resources. Primary among these are historic period shipwrecks. Given the continual river flow and associated sedimentary erosion, deposition, and reworking, it is highly unlikely that any more ephemeral cultural material remains on the river bed. Historic research and bathymetric surveys are conducted to determine if any wrecks are likely to be present prior to construction.

The construction of revetments can potentially have adverse effects on cultural resources. As with other training structures work is conducted via barge, without recourse to land access. The placement of the rock, however, has the potential to damage or destroy any resource on the bankline. With all revetment segments, historical research is conducted on the proposed location to determine if it is on recently accreted land or cut-banks in an existing, older, landform. Recently accreted land is highly unlikely to contain deeply buried cultural resources. If necessary terrestrial surveys are conducted to determine if any cultural resources are present.

Long term impacts of the river training structures is continued bankline stability, reducing the likelihood of cultural resources being damaged or destroyed by erosion.

Continued dredging operations under the No Action Alternative are not anticipated to impact any known historic and cultural resources in the work area. Any undocumented historic and cultural resources that may have existed in the work area likely would have been destroyed by previous dredging and disposal activities. Future maintenance dredging and disposal 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.

The Proposed Action would have no impact on known historic resources and impacts to unknown resources are very unlikely. As such, the past, present, and future impacts to historic and cultural resources of No Action and the Proposed Action, are not anticipated to rise to the level of being significant.

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

REGULATING WORKS PROJECT
MOSENTHEIN/IVORY LANDING PHASE 5
MIDDLE MISSISSIPPI RIVER MILES 160-162.5
MONROE COUNTY, IL
ST. LOUIS COUNTY, MO

JUNE 2015

APPENDIX D
CLEAN WATER ACT
SECTION 404(b)(1) Evaluation

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APPENDIX D

CLEAN WATER ACT
SECTION 404(b)(1) Evaluation

1. PROJECT DESCRIPTION

A. Location. The Mosenthein/Ivory Landing Phase 5 work area is located in the Middle Mississippi River (MMR) between river miles (RM) 160 and 162.5 in St. Louis County, Missouri, and Monroe County, Illinois. The MMR is defined as that portion of the Mississippi River that lies between its confluences with the Ohio and Missouri Rivers.

B. General Description. The Corps of Engineers St. Louis District is proposing to construct the Mosenthein/Ivory Landing Phase 5 work as part of its Regulating Works Project. The Regulating Works Project utilizes bank stabilization and sediment management to maintain bank stability and ensure adequate navigation depth and width. Bank stabilization is achieved by revetments, while sediment management is achieved by river training structures, i.e. dikes and weirs. The Mosenthein/Ivory Landing Phase 5 work is designed to address repetitive maintenance dredging conditions in the area. The work involves construction of three dikes 161.1 -161.7 (L), and placement of weirs at four locations on the right descending bank from river mile 162.0 to 162.3.

C. Authority and Purpose. The Middle Mississippi River Regulating Works Project is specifically and currently authorized pursuant to Rivers and Harbors Acts beginning in the mid-1800's. These authorize USACE to provide a 9-foot-deep by minimum of 300-foot-wide, with additional width in the bends, navigation channel at low river levels.

The purpose of this work is to provide a sustainable, safe and dependable navigation channel through regulation works to reduce the need for repetitive channel maintenance dredging in the area.

D. General Description of the Fill Material.
Fill material would include quarry run limestone consisting of graded "A" stone. Size requirements for graded "A" stone are shown below in Table 1. Stone (165,100 tons) required for construction would be obtained from commercial stone quarries in the vicinity of the work area capable of producing stone which meets USACE specifications.

Table 1- GRADED "A" STONE	
Stone Weight (LBS)	Cumulative % Finer by Weight
5000	100
2500	70-100
500	40-65
100	20-45
5	0-15
1	0-5

E. Description of the Proposed Placement Site.
The proposed work would consist of the following (see Table 2):

Construction of three dikes between river miles 160.1 and 160.7 (L)

- Approximately 330, 500, and 615 linear feet.
- Top elevation of 384 feet (NAVD 88) for the two downstream and 385 ft (NAVD88) for upper dike.

Placement of four weirs between river miles 162.0 – 162.3

- Approximately 520, 645, 720 and 700 linear feet.
- Top elevation of approximately 351 feet (NAVD88).

Table 2 – Mosenthein-Ivory Landing Phase 5 Construction

Middle Mississippi Reach	Site Specific Reach	River Mile	Structure	Elevation (NAVD 88)	Volume (tons)	Approximate Length
Mosenthein/ Ivory Landing Phase V (RM 165-156)	Mouth of the Meramec (RM 162.5-160)	162.30R	Weir	351	8,200	520
		162.20R	Weir	351	7,700	645
		162.10R	Weir	351	12,500	720
		162.00R	Weir	351	12,100	700
		161.70L	Rootless Dike	385	30,500	615
		161.50L	Rootless Dike Extension	384	36,900	500
		161.10L	Rootless Dike Extension	384	57,200	330
			Total Rock Volume (approximate)		165,100	

F. Description of the Placement Method.
Placement of material would be accomplished by track hoe or dragline crane. Stone would be transported to placement sites by barges. All construction would be accomplished from the river and all work would be performed below ordinary high water.

2. FACTUAL DETERMINATIONS

A. Physical Substrate Determinations

I. **Elevation and Slope.**

Dikes

There would be an immediate change in substrate elevation and slope over the areal extent of the dike locations 161.1-161.7 (L). The dikes would consist of a rock mound of uniform shape, between 330 and 615 feet long, placed approximately 600 to 1000 feet off the existing bankline and extending toward the navigation channel. The top elevation of the dikes would be 384 and 385 feet NAVD88. Side slopes would be approximately 1 vertical on 1.5 horizontal. After placement, sediment patterns in the immediate vicinity of the structures would change with scour occurring off both ends of the dikes. Areas immediately downstream of the dikes would experience some areas of accretion and some areas of scour.

- These “rootless” dikes will be placed along the LDB side of the channel in an effort to increase the energy in the navigation channel, resulting in increased depths and a reduction in the need for repetitive channel maintenance dredging.
- The configuration of these dike structures, specifically the “rootless” feature, is an effort to increase the environmental benefits that may result from the construction of these dikes.
- The structures will be constructed of Graded A-Stone (Limestone) placed from floating plant (no bankline access needed).
- The benthic habitat area of the dikes at RM 162.3 – 162.0 is approximately 3.5 acres.

Weirs

There would be an immediate change in substrate elevation and slope over the areal extent of the weir locations between RM 162.0-162.3 (R). The weirs would consist of a rock mound of uniform shape, between 720 and 520 feet long, placed approximately 400 feet off the existing bankline and extending toward the navigation channel. The top elevation of the weirs would be 351 feet (NAVD88). Side slopes would be approximately 1 vertical on 1.5 horizontal on the upstream side and 1 vertical on 3 horizontal on the downstream side. After placement, the elevation of crossover areas downstream of the weirs would experience some reduction.

- By reducing scouring action along the outside bend between RM 162.3 and 162.0, these 4 bendway weir structures (built so that barge tows can pass over the top of the submerged structures) should increase the scouring energy in the area just downstream, which has been an area needing repetitive dredging to maintain a safe and dependable navigation channel.
- The structures will be constructed of Graded A-Stone (Limestone) placed from floating plant (no bankline access needed).
- The benthic habitat area of the weirs at RM 162.3 – 162.0 is approximately 4 acres.

II. **Sediment Type.** The work area is located entirely within the existing channel of the Middle Mississippi River. The Middle Mississippi River channel is comprised mainly of sands with some gravels, silts, and clays. The stone used for construction would be Graded "A" limestone.

III. **Fill Material Movement.** No bank grading or excavation would be required for placement of stone. Draglines and/or track hoes would pull rock from floating barges and place the material into the river and on the banks. Fill materials would be subject to periodic high flows which may cause some potential movement and dislodging of stone. This may result in the need for minor repairs; however, no major failures are likely to occur.

IV. **Physical Effects on Benthos.** Material placement should not significantly affect benthic organisms. Shifting sediments at structure placement sites likely harbor oligochaetes, chironomids, caddisflies, turbellaria, and other macroinvertebrates. High densities of hydropsychid caddisflies and other macroinvertebrates would be expected to colonize the large limestone rocks after construction. Fish would temporarily avoid the area during construction. Greater utilization of the location by fish is expected after construction due to the expected increase in densities of macroinvertebrates.

V. **Actions Taken to Minimize Impacts.** Best Management Practices for construction would be enforced.

B. Water Circulation, Fluctuation, and Salinity Determinations

I. **Water.** Some sediments (mostly sands) would be disturbed when the rock used for construction is deposited onto the riverbed. This increased sediment load would be local and minor compared to the natural sediment load of the river, especially during high river stages.

II. **Current Patterns and Circulation.** The rootless dikes would create split flow conditions at river stages below the top structure elevations of 384 and 385 feet NAVD88. The rootless dikes would increase channel depth in the main channel and along the adjacent bankline. The weirs at 162.0-162.3 (R) would refocus river toward the crossover portion of the channel.

III. **Normal Water Level Fluctuations.** Stages at average and high flows both in the vicinity of the work area and on the MMR are expected to be similar to current conditions. Stages at low flows on the MMR show a decreasing trend over time and this trend is expected to continue with implementation of the Proposed Action.

IV. **Actions Taken to Minimize Impacts.** Best Management Practices for construction would be enforced.

C. Suspended Particulate/Turbidity Determinations

I. **Expected Changes in Suspended Particles and Turbidity Levels in Vicinity**

of Placement Site. Increases in suspended particulates and turbidity due to construction activities are expected to be greatest within the immediate vicinity of the rock structures. The increased sediment load would be local and minor compared to the natural sediment load of the river. This would cease soon after construction completion.

II. **Effects on Chemical and Physical Properties of the Water Column**

a. Light Penetration. There would be a temporary reduction in light penetration until sediments suspended as part of construction activities settled out of the water column.
b. Dissolved Oxygen. No adverse effects expected.
c. Toxic Metals and Organics. No adverse effects expected.
d. Aesthetics. Aesthetics of work sites are likely to be adversely affected during construction, but are expected to return to normal after construction.

III. **Effects on Biota.** The work would likely result in some short-term displacement of biota in the immediate vicinity of construction activities due to temporary decreases in water quality and disturbance by construction equipment.

IV. **Actions Taken to Minimize Impacts.** Impacts are anticipated to be minimized by the use of clean, physically stable, and chemically non-contaminating limestone rock for construction.

D. Contaminant Determinations. It is not anticipated that any contaminants would be introduced or translocated as a result of construction activities.

E. Aquatic Ecosystem and Organism Determinations

I. **Effects on Plankton.** The work could have a temporary, minor effect on plankton communities in the immediate vicinity of the work area. This would cease after construction completion.

II. **Effects on Benthos. S**ediments at structure placement sites likely harbor oligochaetes, chironomids, caddisflies, turbellaria, and other macroinvertebrates. Construction activities would eliminate some of these organisms. High densities of hydropsychid caddisflies and other macroinvertebrates would be expected to colonize the large limestone rocks after construction. Fish would be expected to temporarily avoid the area during construction. Greater utilization of the location by fish is expected after construction due to the expected increase in densities of macroinvertebrates. Fish habitat is expected to improve at the dike placement site due to improved flow, bathymetry, and prey resource conditions.

III. **Effects on Nekton.** Nekton would be temporarily displaced during construction activities, but would return shortly after completion. Greater utilization of the area by fish may occur after construction due to the expected increase in densities of macroinvertebrates and areas of improved flow and bathymetry.

IV. **Effects on Aquatic Food Web.** Temporary reductions in macroinvertebrate and fish communities during construction in the relatively small work area should not significantly impact the aquatic food web in the Middle Mississippi River. Improvements in lower trophic levels (macroinvertebrates) subsequent to completion should benefit the aquatic food web. Minor negative impacts on fish and macroinvertebrate communities due to reduced woody debris should not significantly impact the aquatic food web.

V. **Effects on Special Aquatic Sites.** There are no special aquatic sites within the work area.

VI. **Threatened and Endangered Species.** Presence of, or use by, endangered and threatened species is discussed in the Environmental Assessment and Biological Assessment. The adverse impacts to threatened and endangered species expected to result from this work 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.

VII. **Other Wildlife.** The work would likely result in some very localized, short-term displacement of wildlife in the immediate vicinity of construction activities. Displacement would end immediately after construction completion.

VIII. **Actions Taken to Minimize Impacts.** Best Management Practices for construction would be enforced.

F. Proposed Placement Site Determinations

I. **Mixing Zone Determinations.** The fill material is inert and would not mix with the water. The lack of fine particulate typically contained in rock fill and main channel sediments indicates negligible chemical or turbidity effects resulting from the proposed action.

II. **Determination of Compliance with Applicable Water Quality Standards.** Section 401 water quality certifications have been obtained from the states of Illinois and Missouri (see Appendix F). All other permits necessary for the completion of the work would be obtained prior to implementation.

III. **Potential Effects on Human Use Characteristics.** The proposed work would have no adverse impact on municipal or private water supplies; water-related recreation; aesthetics; or parks, national and historic monuments, national seashores, wilderness areas, research sites or similar preserves. During construction the area would not be available for recreational and commercial fishing.

G. Determinations of Cumulative Effects on the Aquatic Ecosystem. Dikes and weirs have been used extensively throughout the Lower, Middle, and Upper Mississippi River System to provide a safe and dependable navigation channel. Due to concerns from natural resource agency partners about the potential cumulative impacts of river training structures, and other actions within the watershed, on the aquatic ecosystem, the St. Louis District has been utilizing innovative river training structures such as offset dikes to increase habitat diversity in the Middle Mississippi River while still maintaining the navigation channel. The District conducts extensive coordination with resource agency and navigation industry partners to ensure that implementation is accomplished effectively from an ecological and navigation viewpoint. Although minor short-term construction-related impacts to local fish and wildlife populations are likely to occur, only minimal cumulative impacts on the aquatic ecosystem are identified for the Mosenthein/Ivory Landing Phase 5 work.

H. Determinations of Secondary Effects on the Aquatic Ecosystem. No adverse secondary effects would be expected to result from the proposed action.

3. FINDINGS OF COMPLIANCE OR NON-COMPLIANCE WITH THE RESTRICTIONS ON PLACEMENT

A. No significant adaptations of the 404(b)(1) guidelines were made relative to this evaluation.

B. Alternatives that were considered for the proposed action included:

1. No Action Alternative - The No Action Alternative consists of not constructing any new structures in the area but continuing to maintain the existing river training structures. Dredging would continue as needed to address the shoaling issues in the area.
2. Proposed Action - The Proposed Action consists of construction of three dikes at RM 161.1-161.7 (L) and placement of weirs at four locations from RM 162 (R) to 162.3 (R).

C. Certification under Section 401 of the Clean Water Act has been obtained from the Missouri Department of Natural Resources and the Illinois Environmental Protection Agency (see Appendix F).

D. The proposed fill activity is in compliance with Applicable Toxic Effluent Standards of Prohibition under Section 307 of the Clean Water Act.

E. No significant impact to threatened or endangered species is anticipated from this work. Prior to construction, full compliance with the Endangered Species Act would be documented.

F. No municipal or private water supplies would be affected by the proposed action, and no degradation of waters of the United States is anticipated.

G. The work area is situated along an inland freshwater river system. No marine sanctuaries are involved or would be affected by the proposed action.

H. The materials used for construction would be chemically and physically stable and non- contaminating.

I. The proposed construction activity would not have a significant adverse effect on human health and welfare, recreation and commercial fisheries, plankton, fish, shellfish, wildlife, or special aquatic sites. No significant adverse effects on life stages of aquatic life and other wildlife dependent on aquatic ecosystems are expected to result. The proposed construction activity would have no significant adverse effects on aquatic ecosystem diversity, productivity, and stability. No significant adverse effects on recreational, aesthetic, and economic values would occur.

J. No other practical alternatives have been identified. The proposed action is in compliance with Section 404(b)(1) of the Clean water Act, as amended. The proposed action would not significantly impact water quality and would improve the integrity of an authorized navigation system.

2 June 2015
(Date)

ANTHONY P. MITCHELL
COL, EN
Commanding

Appendix E. Public Comments and Responses

Appendix E. Public Comments and Responses

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April 9, 2015

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St. Louis District
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St. Louis, Missouri 63103

Re: Comments on Draft Environmental Assessment for Mosenthein/Ivory Landing Phase V Regulating Work Projects; Public Notice P-2919 (2015-105)

Dear Mr. McClendon:

The National Wildlife Federation appreciates the opportunity to submit these comments on the Draft Environmental Assessment with Unsigned Finding of No Significant Impact, Mosenthein/Ivory Landing Phase V Regulating Work Projects (the Phase V EA).

The National Wildlife Federation (NWF) is the Nation's largest conservation education and advocacy organization. NWF has more than 5.8 million members and supporters and conservation affiliate organizations in forty-nine states and territories. NWF has a long history of interest and involvement in the programs of the U.S. Army Corps of Engineers (Corps) and the management and protection of the Mississippi River. NWF is a strong supporter of ecologically sound efforts to restore the Mississippi River and the nation's many other damaged rivers, coasts, and wetlands.

General Comments

The Phase V EA proposes construction of more than three-quarters of a mile (4,030 linear feet) of new river training structures within a two mile stretch of the Middle Mississippi River that already contains at least 66 such structures. The Phase V project will permanently bury more than three-quarters of a mile of river bottom habitat under 165,100 tons of rock.

The Phase V EA fails to provide the level of analysis needed to evaluate the environmental consequences of this enormous array of new river training structures, and does not comply with the requirements of the National Environmental Policy Act (NEPA). Among other problems, the Phase V EA: (a) fails to demonstrate project need and fails to establish why this project constitutes a wise use of federal taxpayer dollars; (b) fails to review an appropriate range of alternatives; (c) fails to adequately assess hydrologic impacts, including increased flood risks; (d) and fails to meaningfully assess a host of environmental impacts, including the loss of diverse river habitats, impacts to endangered species, and impacts to other fish and wildlife.

Despite many decades of planning and constructing river training structures, the Corps has failed to develop an appropriate model to evaluate the potential impacts from such structures. The Phase V EA instead relies on a physical micro-model that has been demonstrated to lack predictive capability. The Corps should be using state of the art two-dimensional and three-dimensional hydrodynamic models with inputs that recognize the current conditions of the river system.

Despite the undeniable loss of habitat and fundamental morphological changes wrought by river training structures over the many decades that the Corps has been constructing them, the Corps still has not carried out the types of studies that allow a meaningful assessment of the impacts of river training structures on fish and wildlife, the river ecosystem, and public safety. The Phase V EA is utterly lacking in any meaningful assessment of potential impacts to fish and wildlife and the diverse river habitats that they rely on.

Despite extensive peer-reviewed science demonstrating the role of river training structures in increasing flood heights, the Phase V EA continues to disagree with and attack this science. As a result, the Phase V EA does not effectively evaluate the significant risks to public safety created by river training structures in the Mississippi River and does not meaningfully evaluate alternative approaches to reducing those risks.

The National Wildlife Federation repeats is call to the Corps to initiate a National Academy of Sciences study on the effect of river training structures on flood heights to inform its decision making in the Regulating Works Project and beyond. A National Academy of Sciences review is critical for ensuring that the Corps is making decisions based on the best possible scientific understanding of the role of river training structures on increasing flood heights, and for ensuring that the Corps' activities will provide the highest possible protection to the public.

Detailed Comments

A. The Corps Should Complete the Supplemental Environmental Impact Statement for the Regulating Works Program Before Making a Decision on the Phase V Project

The National Wildlife Federation strongly supports the Corps' ongoing preparation of a supplemental environmental impact statement (SEIS) for the Middle Mississippi River Regulating Works Project. NWF urges the Corps to withdraw the Phase V EA and instead use the SEIS to evaluate the proposed Phase V project – and the Corps' other pending river training structure proposals.

This approach would help ensure that the impacts and long-term implications of the Phase V project will be fully assessed, and allow an appropriate evaluation of whether less environmentally damaging alternatives are available.[1] This approach would also give the Corps the time to correct the many

[1] The Phase V EA, which evaluates construction of only one set of new river training structures, cannot satisfy the requirements of NEPA as it would constitute an impermissible piecemeal assessment of just one of the many activities carried out under the Regulating Works Program.

problems with the substantive adequacy of the Phase V assessments and ensure that the Phase V project makes sense in light of a full and comprehensive review of the Regulating Works Project.

As noted above, the National Wildlife Federation also urges the Corps to initiate a National Academy of Sciences study on the effect of river training structures on flood heights to inform its decision making in the Regulating Works Project and beyond. A National Academy of Sciences review is critical for ensuring that the Corps is making decisions based on the best possible scientific understanding of the role of river training structures on increasing flood heights, and for ensuring that the Corps' activities will provide the highest possible protection to the public.

B. The Phase V EA Fails to Demonstrate That the Project is Needed And Authorized

The Phase V EA is deficient because it fails to demonstrate a need for the proposed project. Properly demonstrating project need is fundamental to an adequate NEPA review. It is absolutely critical in this case given that threat to public safety posed by the Phase V project (see section D.1. below) and the fact that the current dredging regime is clearly able to effectively maintain safe and reliable navigation in this portion of the Mississippi River.

The Phase V EA concludes that the project is needed because:

> "Frequent dredging has been required in the area of the proposed Regulating Works, Mosenthein/Ivory Landing Phase 5 construction work area (Mosenthein/Ivory Landing Phase 5 work area; see a detailed discussion of this in Section 3, Affected Environment)." Therefore, after analysis of this area, the District concluded that construction of the Mosenthein/Ivory Landing Phase 5 work area is reasonable and necessary to address the repetitive channel maintenance dredging in order to provide a sustainable, less costly navigation channel in this area. The District has concluded through analysis and modeling that construction of river training structures would provide a sustainable alternative to repetitive maintenance dredging."

EA at 2.

Despite the stated purpose of reducing the need for repetitive dredging, the Phase V EA provides only the most generalized information on the amount and costs of dredging in the general area where the proposed project will be carried out: "[o]ver the last ten years dredging costs in the area (RMs 156 – 165) have averaged approximately $359,925 per year. These expenditures would be expected to continue in the future." EA at22. This cost estimate covers a substantially larger portion of the river – 5 extra miles – then the portion of the river where the Phase V projects will be carried out and fails to address whether unique circumstances existed during this time period that may have affected the dredging regime. The Phase V EA acknowledges that some of the Phase V project river training structures are to be constructed in an area that has seen a low frequency of dredging, further calling into question the need and appropriateness of the project. EA at 3, Figure 3.

The Corps' cursory statements fail to provide a meaningful assessment of project need. To assist the public and decision makers in determining whether all or a portion of the Phase V projects are both needed and a wise use of taxpayer dollars, the Phase V EA should provide the information outlined below in addition to fully assessing the project's environmental impacts:

(1) The specific history of dredging over the past 20 years (through a yearly breakdown of amounts and costs) within the two mile stretch of river covered by the proposed Phase V project.[2]
(2) An analysis of whether any of the dredging carried out in the two mile stretch during this 20 year history was the result of unique circumstances, such as the back to back 2011 flood and 2012 drought, and whether such unique circumstances are likely to re-occur.
(3) The number of times, if any, when navigation in the two mile stretch of river covered by the proposed Phase V project could not be maintained through dredging.
(4) The projected future costs of required dredging under the no action alternative calculated for the full life of the proposed Phase V project, and an assessment of the ability to maintain navigation in the project area through dredging alone.
(5) The construction[3] and full life cycle maintenance costs of the proposed Phase V project.
(6) The projected amount and costs of the dredging that will still be needed if the Phase V project is constructed. The Phase V EA makes clear that maintenance dredging will still be required even if the Phase V project is constructed, as implementation of the project is only "expected to reduce the amount and frequency of repetitive maintenance dredging necessary in the area." EA at 22. Since maintenance dredging would continue after construction of the Phase V projects, a meaningful assessment must include an accurate comparison of the future amount and costs of maintenance dredging both with and without the proposed project in place.
(7) The increased risks of upstream or nearby levee failures should the proposed project increase flood heights; and the projected costs of any needed repairs.
(8) The value of the ecosystem services that will be lost as a result of the Phase V project, which should be accounted for as a project cost.[4]

This information would assist the public and decision makers in assessing both the need for, and the true costs and benefits of, the project. Without such information it is not possible to make a reasonable determination of whether the proposed project is needed, whether it will reduce the costs of maintenance dredging, whether it is a wise investment of scarce taxpayer dollars, or whether it meets the Corps' stated goal of identifying "a long-term sustainable solution" that is "reasonable." EA at 1.

[2] While some additional information on dredging is included in the HSR District's Technical Report M68, *The Mouth of the Meramec River HSR Model, Mississippi River, River Miles 165.00 – 156.00, Hydraulic Sediment Response Model Investigation* (USACE 2014), even this report does not include all the information required to meaningfully assess whether these projects are in fact needed. Moreover, none of this additional information is provided in the Phase V EA or the Appendices to the Phase V EA.
[3] The Environmental Assessment states that the cost of the proposed Phase V project "is not expected to exceed" $3.5 million, but fails to provide any assessment of how that number was reached. It also fails to provide life cycle maintenance costs or the costs of dredging that will need to continue even if the proposed project is constructed. The Environmental Assessment also does not provide a benefit-cost analysis for the proposed project.
[4] Final Interagency Guidelines for the Principles and Requirements for Federal Investments in Water Resources (March 2013) at 21 ("Ecosystems provide services to people. Thus, Federal investment impacts on the environment or ecosystem may be understood in terms of changes in service flows. The process of identifying, evaluating, and comparing these changes provides a useful organizing framework to produce a complete accounting. **Reduced service flows over time amount to costs**, and increased services flows over time amount to benefits." (emphasis added)).

The Phase V EA should also clearly document whether any actions proposed in the EA can be carried out under the existing authorization, or whether new authorization from Congress would be required. According to the Phase V EA and the 1976 EIS for the "Mississippi River Between the Ohio and Missouri Rivers (Regulating Works)", prepared by the Corps' St. Louis District, the Regulating Works Project is authorized by the Rivers and Harbors Act of 1910, the Rivers and Harbors Act of 1927 and the Rivers and Harbors Act of 1930. Each of these Acts authorizes activities recommended in a Chief of Engineers Report prepared prior to enactment of each Act. These Chief of Engineers Reports are not readily accessible to the public, and the text of the reports was not provided in either the Phase V EA or the 1976 EIS. However, NWF has been able to locate and review these reports.

Our review strongly suggests that the Regulating Works Project did not intend to authorize ongoing river training structure construction for period of more than 100 years, but instead was far more limited in both scope, time, and costs. If our assessment is correct, new Congressional authorization would likely be required to carry out any additional construction of river training structures.[5] The Phase V EA should provide the public and decision makers with the precise language of the Chief's Reports and authorizing language and provide an explanation of why the Corps has interpreted this language to allow for continuous and substantial construction of new river training structures. This would provide the public and decision makers with a clearer understanding of the precise activities currently authorized (including any limitations on those activities) and whether new authorization would be required.

C. The Phase V EA Fails to Evaluate a Reasonable Range of Alternatives

An environmental assessment, like an environmental impact statement, "must evaluate a reasonable range of alternatives to the agency's proposed action, to allow decision-makers and the public to evaluate different ways of accomplishing an agency goal."[6] This is because the consideration of alternatives required by NEPA is both independent of, and broader than, the requirement to prepare an environmental impact statement.[7] As a result "[c]onsideration of alternatives is critical to the goals of NEPA even where a proposed action does not trigger the EIS process."[8]

The Phase V EA is legally insufficient because it does not examine a reasonable range of alternatives. It looks only at the proposed alternative and the no action alternative.[9] Additional alternatives that should be examined include, but are by no means limited to:

[5] It is also possible that the numerous other river training structure projects currently being carried out or planned by the Corps also exceed the existing authorization, and thus cannot be constructed without new Congressional authorization.

[6] *Pacific Marine Conservation Council v. Evans*, 200 F. Supp. 2d 1194, 1206 (N.D.Cal 2002); *Akiak Native Community v. United States Postal Serv.*, 213 F.3d 1140, 1148 (9th Cir. 2000) (EA must consider a reasonable range of alternatives).

[7] *Bob Marshall Alliance v. Hodel*, 852 F.2d 1223 (9th Cir. 1988), *cert. denied*, 489 U.S. 1066 (1988); *City of New York v. United States Department of Transportation*, 715 F.2d 732, 742 (2d Cir.1983), *cert. denied*, 465 U.S. 1055 (1984); *Environmental Defense Fund, Inc. v. Corps of Engineers*, 492 F.2d 1123, 1135 (5th Cir.1974).

[8] *Bob Marshall Alliance*, 852 F.2d at 1228-29.

[9] While other configurations of river training structures were examined prior to preparation of the environmental assessment, this does not exempt the Corps from the requirement to examine a reasonable range of alternatives in the EA. Moreover, evaluations of alternative configurations of river training structures cannot satisfy the

(1) Utilizing restoration measures to reduce sedimentation in the navigation channel and/or otherwise reducing the need for dredging the navigation channel.
(2) Removing and/or modifying existing river training structures to reduce flood risks and restore backwater, side channel, and braided habitat.
(3) Maintaining the authorized navigation channel through alternative approaches, including such things as alternative dredging strategies, and/or removing sediment dredged from the river rather than pumping dredged sediment back into the river adjacent to the main channel.
(4) Minimizing the use of new structures, including by placing restrictions on the number and/or types of structures that can be utilized in a given reach based on a robust scientific assessment of the cumulative impacts of the various types of river training structures.

Each alternative **must** include mitigation for any unavoidable adverse impacts as required by 33 U.S.C. § 2283(d) and the Clean Water Act.

To comply with the National Water Resources Planning Policy established by Congress in 2007, the Phase V EA must evaluate alternatives that would protect and restore the natural functions of the Mississippi River, and must ultimately select an alternative that achieves these objectives. That policy states that "all water resources projects" shall "protect[] and restor[e] the functions of natural systems and mitigat[e] any unavoidable damage to natural systems." 33 U.S.C 1962-3 (established by § 2031(a) of the Water Resources Development Act of 2007, and immediately applicable to all water resources projects).[10]

The decision making process identified at page 4 of the EA does not satisfy the requirements of NEPA or the National Water Resources Planning Policy. EA at 4 ("Ameren representatives voiced concern about impacts to the Ameren facility in the area. The USFWS questioned why several alternatives that required less placement of rock, but seemed to yield satisfactory navigation channel results, were not considered. Ultimately, USACE chose Alternative 16 because it lowered the main channel elevation the most and was supported by agencies participating in the April 17, 2014, HSR Model Coordination Meeting.")

The failure to comply with NEPA (which among many other things requires identification of less environmentally damaging alternatives) and the National Water Resources Planning Policy can be seen

requirement to evaluate a reasonable range of alternatives because each alternative would have the same end result – construction of river training structures in the project area. *State of California v. Block*, 690 F.2d 753, 767 (9th Cir. 1982) (holding that an inadequate range of alternatives was considered where the end result of all eight alternatives evaluated was development of a substantial portion of wilderness).

[10] Enhancement of the environment has been an important federal objective for water resources programs for decades. Corps regulations in place since 1980 state that: "Laws, executive orders, and national policies promulgated in the past decade require that the quality of the environment be protected and, where possible, enhanced as the nation grows. . . . Enhancement of the environment is an objective of Federal water resource programs to be considered in the planning, design, construction, and **operation and maintenance of projects**. Opportunities for enhancement of the environment are sought through each of the above phases of project development. Specific considerations may include, but are not limited to, **actions to preserve or enhance critical habitat for fish and wildlife; maintain or enhance water quality; improve streamflow**; preservation and restoration of certain cultural resources, **and the preservation or creation of wetlands."** 33 C.F.R. § 236.4. (emphasis added).

from the notes to the HSR Model Coordination Meeting referred to in (but not attached to) the Phase V EA). These notes clearly show that even within the extremely limited context of the HSR modeling effort, less environmentally damaging options were available:

> "Matt Mangan of USFWS thought Alternatives 3, 4, and 6 achieved similar results as Alternative 16 while requiring less construction. Therefore, USFWS recommended a less aggressive, phased approach to minimize impacts to the environment. The USACE – St. Louis District agree that alternatives 3, 4, and 6 did achieve favorable results, the results of the alternative 16 were more favorable. During the HSR meetings there was no mention of Pallid Sturgeon, Least Tern, or any other form of habitat impact, so our plan is to move forward with alternative 16. Furthermore, the St. Louis District will evaluate the use of phased construction for the project."

D. The Phase V EA Fails to Properly Evaluate the Full Suite of Impacts to the Environment

The Phase V EA fails to evaluate the full suite of impacts, provides only the most limited analysis of those impacts it does evaluate, and fails to provide a reasonable explanation between the information presented and the conclusions drawn. The Phase V EA also appears to ignore important information already assembled by the Corps on relevant impacts of the Regulating Works project. This includes extensive scientific information developed under the Long Term Resources Monitoring Program on navigation-related activities that have harmed the ecological health of the Mississippi River, and information utilized by the Corps when it "determined that there is sufficient significant new information regarding the potential impacts of the [Regulating Works] project on the human environment to warrant the preparation of a supplemental environmental impact statement." 78 Fed. Reg. 77108 (December 20, 2013).

In comparing and analyzing potential alternatives, the Phase V EA must examine, among other things, the direct, indirect, and cumulative environmental impacts of alternatives, the conservation potential of those alternatives, and the means to mitigate adverse environmental impacts that cannot be avoided. 40 C.F.R. § 1502.16. This assessment is essential for determining whether less environmentally damaging alternatives are available.

Direct impacts are caused by the action and occur at the same time and place as the action. Indirect impacts are also caused by the action, but are later in time or farther removed from the location of the action. 40 C.F.R. § 1508.8. Cumulative impacts are:

> "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 C.F.R. § 1508.7. The cumulative impacts analysis ensures that the agency will not "treat the identified environmental concern in a vacuum."[11] The cumulative impacts analysis must examine the

[11] *Grand Canyon Trust v. FAA*, 290 F.3d 339, 346 (D.C. Cir. 2002).

cumulative effects of federal, state, and private projects and actions;[12] and the cumulative impacts of climate change.[13]

The Phase V EA must provide "quantified or detailed information" on the impacts, including the cumulative impacts, so that the courts and the public can be assured that the Corps has taken the mandated hard look at the environmental consequences of the Project.[14] **If information that is essential for making a reasoned choice among alternatives is not available, the Corps must obtain that information unless the costs of doing so would be "exorbitant."** 40 C.F.R. § 1502.22 (emphasis added).

Importantly, as CEQ has made clear, in situations like those in the Mississippi River where the environment has already been greatly modified by human activities, it is **not** sufficient to compare the impacts of the proposed alternative against the current conditions. Instead, the baseline must include a clear description of how the health of the resource has changed over time to determine whether additional stresses will push it over the edge.[15]

1. The Phase V EA Fails to Properly Evaluate Hydrologic Impacts

It is essential that the Corps properly assess the impacts of the project on flood heights, channel morphology, and diverse river habitats. Absent meaningful assessments of these impacts, it is not possible to assess the impacts of the proposed project on fish and wildlife or public safety; and it is not possible to assess whether the proposed project will in fact reduce – rather than simply relocate – dredging needs.

(a) The Phase V EA Relies on a Fundamentally Flawed and Wholly Unreliable Model to Attempt to Evaluate the Impacts of the Project

The Phase V EA relies on a fundamentally flawed and wholly unreliable HSR model. Because this flawed model drives the assessment of all hydrologic and habitat changes assessed in the Phase V EA, it makes the entire Phase V EA unreliable.

The proposed alternative was developed using a Hydraulic Sediment Response model (HSR model) that

[12] The requirement to assess non-Federal actions is not "impossible to implement, unreasonable or oppressive: one does not need control over private land to be able to assess the impact that activities on private land may have" on the project area. *Resources Ltd., Inc. v. Robertson*, 35 F.3d 1300, 1306 (9th Cir. 1993).
[13] *See Center for Biological Diversity v. Nat'l Hwy Traffic Safety Administration*, 538 F.3d 1172, 1217 (9th Cir. 2008) (holding that analyzing the impacts of climate change is "precisely the kind of cumulative impacts analysis that NEPA requires agencies to conduct" and that NEPA requires analysis of the cumulative impact of greenhouse gas emissions when deciding not to set certain CAFE standards); *Center for Biological Diversity v. Kempthorne*, 588 F.3d 701, 711 (9th Cir. 2009) (NEPA analysis properly included analysis of the effects of climate change on polar bears, including "increased use of coastal environments, increased bear/human encounters, changes in polar bear body condition, decline in cub survival, and increased potential for stress and mortality, and energetic needs in hunting for seals, as well as traveling and swimming to denning sites and feeding areas.").
[14] *Neighbors of Cuddy Mountain v. U. S. Forest Service*, 137 F.3d 1372, 1379 (9th Cir. 1998); *Natural Resources Defense Council v. Callaway*, 524 F.2d 79, 87 (2d Cir. 1975).
[15] Council on Environmental Quality, Considering Cumulative Effects Under the National Environmental Policy Act at 41 (January 1997).

is a "small-scale physical sediment transport model used by the District to replicate the mechanics of river sediment transport." Phase V EA at 4. However, HSR models have been shown to be completely unreliable for planning purposes as they lack "predictive capability". Stephen T. Maynord, Journal of Hydraulic Engineering, *Evaluation of the Micromodel: An Extremely Small-Scale Movable Bed Model* (April 2006). Maynord concludes that because of the "lack of predictive evidence, the micromodel should be limited to demonstration, education, and communication." A copy of this study is attached to these comments at Attachment A.

The Phase V EA recognizes at least some of the failings of the HSR model, particularly noting that the model's small scale prevents a full assessment of the hydrologic impacts: "The rootless Dike 161.50 was placed at an angle in an attempt to divert a small amount of additional flow towards the small side channel located along the left descending bank. **It should be noted that throughout testing, no sediment movement was observed within the side channel; however, at the model's scale it may not have been observable.** Overall, this alternative enhanced navigation safety for industry by providing a deeper navigation channel while maintaining **and potentially creating** additional channel border habitat within the work area." EA at 4 (emphasis added).

In addition, the HSR model can provide a non-predictive prototype only on a local basis and over short time scales. This approach and the Phase V EA as a whole fail to recognize that this incremental approach in no way addresses system-wide changes to the Middle Mississippi River system. This model also cannot evaluate whether the new surge in construction of training structures in the past several years has simply shifted the loci of sedimentation which could eventually lead to even more river training structure construction.

In carrying out its hydrologic analysis the Corps should utilize the most up-to-date modeling to evaluate the potential impacts of each alternative such as by using state of the art two-dimensional and three-dimensional hydrodynamic models with inputs that recognize the current conditions in the river system. The Corps should abandon its use of micro models to evaluate the impacts of river training structures (including the Corps' Hydraulic Sediment Response or HSR model) as such models cannot be relied upon to provide accurate planning information as they lack "predictive capability".[16]

Because of these failings, the public and decision makers cannot know what the impacts of the proposed Phase V project will be on the river channel and river habitat, on flooding, on the ecological health of the river, or on fish and wildlife.

(b) The Phase V EA Incorrectly Rejects Overwhelming Scientific Evidence Showing That River Training Structures Significantly Increase Flood Risks

The National Wildlife Federation recognizes that the Corps has consistently disagreed with the extensive peer-reviewed science demonstrating the role of river training structures in increasing flood heights, and that the Corps has repeatedly attempted to establish that this science is based, in part, on a flawed data set. *See, e.g.*, EA at 14. NWF also recognizes that much of the Corps' argument in this regard is set forth in Appendix A to the Phase V EA.

[16] Stephen T. Maynord, Journal of Hydraulic Engineering, Evaluation of the Micromodel: An Extremely Small-Scale Movable Bed Model (April 2006).

However, highly respected independent scientists along with the National Wildlife Federation and many other conservation organizations, strongly disagree with the Corps' conclusions on this science. An extensive rebuttal to the Corps' conclusions have been set forth in two Declarations prepared by Dr. Nicholas Pinter, both of which are attached to these comments at Attachment B.

National Wildlife Federation wishes to highlight that the science shows that in the Upper Mississippi River, flood stages increase by more than 4 inches for each 3,281 feet of wing dike built within 20 river miles downstream. Declaration of Nicholas Pinter at paragraph 19; Reply Declaration of Nicholas Pinter at paragraph 24 (both found at Attachment B to these comments). This means that the Phase V projects (4,030 linear feet of new river training structures) could increase flood heights by 4.9 inches for 20 miles upstream from just these projects.

NWF also notes that even the studies commissioned by the St. Louis District and cited in the Phase V EA (e.g., Watson et al., 2013a) find statistically significant increases in water levels for flood flows. Watson 2013 and the Corps' assessment in Appendix A, minimize some flood-level increases and eliminate all others through incorrect "data assassination." Both analyses consider only: the Middle Mississippi River; only two stage gauges on the Middle Mississippi (at Chester and St. Louis); and only a limited record of data.

Since 1986, at least 51 scientific studies have been published linking the construction of river training structures to increased flood heights. More than 15 studies published from 2000-2010 demonstrate the role of river training structures on flood heights in the Mississippi River. These studies show that river training structures constructed by the Corps to reduce navigation dredging costs have increased flood levels by 10 to 15 feet and more in some locations of the Mississippi River during large floods. Independent scientists have also determined that the more than 40,000 feet of "wing dikes" and "bendway weirs" constructed by the Corps in the Mississippi during the 3 years prior to the great flood of 1993 contributed to record crests in 1993, 1995, 2008, and again in 2011. A list of the 51 studies assessing the role of instream structures on increasing flood heights is attached to these comments at Attachment C. NWF requests that these studies be included in the record for this project.

In light of the significant risks to public safety posed by the Corps' ongoing objection to well settled science, National Wildlife Federation once again strongly urges the Corps to initiate a National Academy of Sciences study to evaluate this issue. We note that such a study could be undertaken for the cost of just a portion of the proposed Phase V project, and that ensuring public safety is more than worthy of such a limited investment of funds. We also note that the burden of proof is on the Corps to establish the safety and efficacy of river training structures *before* building any additional structures.

2. The Phase V EA Fails to Adequately Evaluate Impacts to Fish and Wildlife, Including Endangered Species

The Mississippi River is used by an astounding array of wildlife, including 360 species of birds, 260 species of fish, 145 species of amphibians and reptiles, 98 species of mussels, and 50 species of mammals. Forty percent of North America's waterfowl migrate through the Mississippi River flyway. An accurate assessment of fish and wildlife impacts will require an accurate assessment of impacts to the full range of habitats that these species rely on.

The Phase V EA must examine the direct, indirect, and cumulative impacts on fish and wildlife. Direct impacts from this project include the impacts of construction and the impacts of burying more than three-quarters of a mile of the river bottom under 165,100 tons of rock. Indirect impacts will result from, among other things: changes to the river habitat, including loss of diverse habitats such as side channels, braided channel, crossover habitat, mid-channel bars, backwater habitat, riverine wetlands, and floodplain wetlands; changes to sedimentation patterns; and increased traffic. To fully assess the potential impacts from the proposed Phase V project the EA must carefully evaluate and quantify the potential for such habitat changes that can have cascading negative impacts on fish and wildlife.

Because the Corps has relied almost exclusively on the flawed and non-predictive HSR model to evaluate hydrologic and habitat changes, the Phase V EA does not – and cannot – evaluate the true scope of direct, indirect, and cumulative impacts to fish and wildlife. The Phase V EA also fails to identify the habitat needs of fish and wildlife species (and only generally mentions the types of fish and macroinvertebrates that might be found in the project area), adding significantly to the inadequacy of the Phase V EA.

The Corps has not conducted the modeling or monitoring needed to draw the conclusion that the project will have no adverse impacts to fish and wildlife. For example, as discussed elsewhere in these comments, the Phase V EA fails to adequately assess the hydrologic and cumulative impacts and thus it has no basis for assessing the resulting changes in habitat for fish and wildlife species.

Critically for the evaluation of fish and wildlife impacts, the Phase V EA also essentially ignores the large-scale loss of backwater and side channel habitat in the Mississippi River and the potential for additional losses of natural side channels, crossover habitat and mid-channel bars if the proposed project is constructed. The Corps' vague reference to using innovative designs and to other Corps programs working to restore and preserve this type of habitat does not cure this critical failing.

(a) Impacts on Side Channel Habitat

The Phase V EA fails to adequately evaluate the extent and resulting fish and wildlife impacts of lost side channel habitats for at least the following four reasons.

First, as noted above, the Corps relies on a flawed and non-predictive HSR model to conclude that side channel habitat will not be lost.

Second, the Phase V EA incorrectly assumes that the average planform width has remained relatively stable over the past four decades, and thus is no longer a key problem of concern for the river. However, this conclusion is contradicted by the information presented in the EA itself, which shows that the river has been losing an average of 4 feet of width each and every year since 1968: "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." EA at 10. And this is of course on top of the significant narrowing of the Mississippi River that occurred prior to 1968.

Third, while acknowledging a link between reduced stage at low flow and loss of side channel habitat (see EA at 14-15), the Phase V EA goes on to improperly conclude that the proposed project will not lead to additional losses of side channel habitat because "any impacts locally or cumulatively are being minimized through the use of innovative river training structures and through other District programs, which have currently seen success in restoring and preserving side channels affected by river training structures." EA at 15. This vague and self-serving conclusion is not, and cannot be, supported by any evidence and is contradicted by the well-recognized fact that river training structures lead to reduced stages at low flows (they raise stages when the river is at flood stage).

Fourth, the Phase V EA essentially ignores the significant body of scientific evidence demonstrating the significant loss of side channel habitat in the Middle Mississippi River and the role of navigation-related activities, including the Regulating Works Project, in those losses. The EA also relies on the fact that revetment has been placed on the river banks to incorrectly conclude that additional side channel loss is not an issue of concern.

Loss of side channel habitat is a tremendous problem on the Mississippi River and preventing additional losses is a key component of the Biological Opinion. Before taking actions that may well result in additional losses of complex river habitat, the Corps should carry out the level of studies and detailed modeling needed to determine what the impacts will actually be on these vital habitats and the fish and wildlife that rely on those habitats.

(b) Impacts on Fish and Wildlife

The Phase V EA fails to provide any meaningful information on potential fish impacts and provides no information on potential wildlife impacts. The EA also fails to provide information on the habitat needs of species in the project area or how those needs might be affected by the project.

The EA acknowledges that the impacts on fish and wildlife will vary widely based on the type of structure and the location of that structure. However, the Phase V EA fails to provide any meaningful information on the impacts on fish from the types of structures that would be built in the Phase V project. As noted above, the EA provides no information on impacts to other wildlife.

For example, the EA provides some limited information on the changes from traditional dikes (perpendicular to the flow and tied in to the river bank), but the Phase V project does not include any of these structures. EA at 18. The EA provides limited information on the impacts of chevrons, but the project does not include any chevrons. EA at 19.

The Phase V EA recognizes that the Corps has only the most extremely limited information upon which to draw any conclusions on fisheries impacts. Given the extensive amount of river training structure construction carried out by the Corps in the Middle Mississippi River, it is unacceptable that they have not done more research on the impacts of these structures on fish and wildlife resources. In the absence of this information, the Corps cannot draw any legitimate conclusions about the potential impacts of the proposed project on fish and wildlife.

Understanding the impacts of the proposed project on vital river habitat and fish and wildlife resources is essential for making a reasoned choice among alternatives. As a result, the Corps must obtain this information unless the overall costs of doing so would be "exorbitant." 40 C.F.R. § 1502.22.

(c) Impacts to Endangered Species

The Phase V EA fails to properly evaluate the impacts to endangered species. While the EA acknowledges that the project may adversely affect endangered species, it goes on to conclude that those impacts would be "only limited" and that "the adverse effects of the work on the pallid sturgeon and 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." EA at 6, 21.

But the Phase V EA fails to provide any evidence to support these conclusions. Minimizing loss of side channel habitat and sand bar habitat are key components of avoiding jeopardy under the Biological Opinion, but as noted above, the Phase V EA fails to acknowledge the significance of the existing losses, and has not conducted the modeling needed to determine that future losses will not be caused by the Phase V project.

It is far more likely that the proposed Phase V project will add to the loss of diverse river habitats, since like other river training structures, their very purpose is to create a deeper, self-scouring channel which in turn leads to losses in natural backwater and braided channel habitats. These impacts are well recognized by the U.S. Fish and Wildlife Service which has concluded that construction of river training structures have adversely affected the pallid sturgeon and least tern by destroying vital habitat.

3. The Phase V EA Fails to Properly Evaluate Cumulative Impacts

The Phase V EA fails to properly evaluate – and account for – cumulative impacts. Notable failings in this section include the failure to assess the cumulative impacts of the Corps' many other activities on the Mississippi River, including already constructed river training structures, and the failure to adequately account for the cumulative impacts of climate change.

Instead of conducting an appropriate cumulative impacts analysis, the Phase V EA inappropriately draws this sweeping, unsupportable, and self-serving conclusion:

> The Regulating Works Project, in combination with the other actions 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 includes involving partner agencies throughout the planning process, avoiding and minimizing environmental impacts, and utilizing innovative river training structure configurations to provide fish habitat while still providing benefits to the navigation system. Although our understanding of the actions that bear upon the resources of the Middle Mississippi River continues to evolve, equilibrium in habitat conditions appears to have been

> reached. Accordingly, only minimal impacts to the resources, ecosystem and human environment are anticipated for the Mosenthein-Ivory Phase 5 work area.

EA at 25.

These summary conclusions do not comport with a significant body of scientific evidence (much of which was prepared with the Corps' input) which document the severe decline in the ecological health of the UMR-IWW system, the fundamental alteration of the Upper Mississippi River's natural processes, and the significant role of navigation related activities in this decline.

In a 1999 report on the Status and Trends of the Upper Mississippi River System, the U.S. Geological Survey concluded that the Corps' O&M activities in the UMR-IWW system were: destroying critical habitats including the rivers' backwaters, side channels and wetlands; altering water depth; destroying bathymetric diversity; causing nonnative species to proliferate; and severely impacting native species.[17] The 1999 Status and Trends Report also rated the health of the Mississippi River System as follows:

1. The Lower Reach of the Illinois River is degraded for all 6 criteria of ecosystem health evaluated by the report.[18]
2. The Unimpounded Reach of the Mississippi River is degraded for 3 criteria, heavily impacted for 2 criteria, and moderately impacted for 1 criterion.
3. The Lower Impounded Reach of the Mississippi River (Pools 14-26) is degraded for 2 criteria, heavily impacted for 3 criteria, and moderately impacted for 1 criterion.
4. The Upper Impounded Reach of the Mississippi River (Pools 1-13) is degraded for 1 criterion and moderately impacted for 5 criteria.

The 1999 Status and Trends report further concluded that no segment of the Upper Mississippi River system was unchanged from historic conditions, or deemed to require no management action to maintain, restore or improve conditions. Equally important, no segment of the system was improving in quality.[19]

In December 2008, the U.S. Geological Survey issued a second report on the status and trends of selected resources in the Upper Mississippi River system which also found that the Corps' O&M activities were causing significant adverse impacts.[20] For example:

> The current condition of the UMRS is heavily influenced by its agriculture-dominated basin and by the dams, channel training structures, dredging, and levees that regulate flow distribution during most of the year. Although substantial improvements in some conditions have occurred

[17] *Id*.
[18] "Degraded" is the lowest possible grade issued by the report and is defined as a condition where the factors associated with the criteria "are now below ecologically acceptable levels" and where "[m]ultiple management actions are required to raise these conditions to acceptable levels." 1999 Status and *Trends Report* at 16-2.
[19] 1999 Status *and Trends Report at* 16-1 to 16.-2.
[20] Johnson, B. L., and K. H. Hagerty, editors. 2008. U.S. Geological Survey, *Status and Trends of Selected Resources of the Upper Mississippi River System,* December 2008, Technical Report LTRMP 2008-T002. 102 pp + Appendixes A–B (Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin) (2008 Status and Trends Report).

since the 1960s because of improvements in sewage treatment and land use practices, the UMRS still faces substantial challenges including

1. High sedimentation rates in some backwaters and side channels;
2. An altered hydrologic regime resulting from modifications of river channels, the floodplain, and land use within the basin, and from dams and their operation;
3. Loss of connection between the floodplain and the river, particularly in the southern reaches of the UMRS;
4. Nonnative species (e.g., common carp [*Cyprinus carpio*], Asian carps [*Hypophtalmichthys* spp.], zebra mussels [*Dreissena polymorpha*]);
5. High levels of nutrients and suspended sediments; and
6. Degradation of floodplain forests.[21]

The 2008 Status and Trends report also recognized that there has been "a substantial loss of habitat diversity"[22] in the system over the past 50 years due in large part to excessive sedimentation and erosion:

> In all reaches, sedimentation has filled-in many backwaters, channels, and deep holes. In the lower reaches, sediments have completely filled the area between many wing dikes producing a narrower channel and new terrestrial habitat. Erosion has eliminated many islands, especially in impounded zones.[23]

In addition to this significant environmental harm, as discussed above, an extensive body of peer-reviewed scientific literature also demonstrates that river training structures constructed by the Corps to help maintain the 9 foot navigation channel are significantly increasing the risks of floods for riverside communities. These structures, constructed by the Corps to reduce navigation dredging costs, have increased flood levels by up to 15 feet in some locations and 10 feet in broad stretches of the river where these structures are prevalent.[24]

(a) Cumulative Impacts of Other Corps Activities on the Mississippi River

The Phase V EA fails to meaningfully evaluate the cumulative impacts of the Corps' many activities on the Mississippi River. These include the full suite of past, present, and reasonably foreseeable future Regulating Works Project activities, navigation operation and maintenance activities, flood damage reduction activities, and other reasonably foreseeable projects.

For example, the Phase V EA fails to discuss the cumulative impacts of the existing river training located

[21] *Id*. at 3.
[22] *Id*. at 6.
[23] *Id*. at 6.
[24] Pinter, N., A.A. Jemberie, J.W.F. Remo, R.A. Heine, and B.A. Ickes, 2010. Empirical modeling of hydrologic response to river engineering, Mississippi and Lower Missouri Rivers. River Research and Applications, 26: 546-571; Remo, J.W.F., N. Pinter, and R.A. Heine, 2009. The use of retro- and scenario- modeling to assess effects of 100+ years river engineering and land cover change on Middle and Lower Mississippi River flood stages. Journal of Hydrology, 376: 403-416.

within the project area. See, EA at 131-135. The HSR model report (though not the Phase V EA) states that there are at least 66 existing river training structures in the project area. The Mouth of the Meramec River HSR Model at 5. However, the HSR report does not indicate the total length or size of these existing structures making it difficult to assess the effects on flood heights and habitat loss. The impacts of these existing structures have not been evaluated in the cumulative impacts assessment.

The Corps similarly appears not to have identified the full list of river training structures currently under construction or in planning for the Regulating Works Program. Compare the list of projects at EA page C-4 to C-5 with the list of projects from the St. Louis District website accessed on April 8, 2015. A copy of this list is attached to these comments at Attachment D. Moreover, the Phase V EA identifies only one additional future project as reasonably foreseeable, even though the Corps clearly believes that it will be constructing many new projects under the Regulating Works Program as it is in the process of supplementing the woefully out of date 1976 Regulating Works Program Environmental Impact Statement.

The numbers of river training structures, and their impacts, are significant. For example, the Phase V EA states that there are "1,375 river training structures on the MMR, which include wing dikes, bendway weirs, chevrons, and other configurations. Of this total, 175 are bendway weirs. The pace of construction has changed over time and the shape, size, elevation and configuration of river training structures has also changed. The St. Louis District built approximately 450 river training structures in the late 19th century and another 250 in the 1930s. The District constructed 150 bendway weirs from 1990 to 2000." EA at C-4.

Information provided to the National Wildlife Federation suggests that between 1980 and 2009, the Corps built at least 380 new river training structures in the Middle Mississippi, including 40,000 feet of wing dikes and bendway weirs between 1990 and 1993. The Corps built at least 23 chevrons between 2003 and 2010.

The Corps also carries out other major operations and maintenance activities that affect the Middle Mississippi River and the entire UMR-IWW. These activities include: dredging and disposal of dredged material, water level regulation, construction of revetment, and operation and maintenance of the system's 37 locks and dams. Maintaining this navigation system requires "continuous regular operations and maintenance" at a cost of more than $120 million each year.[25] The Phase V EA fails to account for the cumulative impacts of any of these other navigation related activities.

In addition, the cumulative impacts analysis must evaluate the cumulative impacts of work carried out by the Corps under its flood damage reduction authority, including the construction and maintenance of Mississippi River levees and reasonably foreseeable future flood damage reduction projects. The cumulative impacts analysis should also evaluate such things as past, present, and reasonably foreseeable future: (a) lock and dam construction; reservoir and dam operations that affect the Mississippi River and its floodplain – including for such facilities located in areas outside of the Mississippi River; (b) residential and commercial development, including road construction, that affects

[25] USACE Brochure, Upper Mississippi River – Illinois Waterway System Locks and Dams (September 2009) available at http://www.mvr.usace.army.mil/brochures/documents/UMRSLocksandDams.pdf; Congressional Research Service, *Inland Waterways: Recent Proposals and Issues for Congress* (July 14, 2011) at 15.

the Mississippi River and its floodplain; and (c) agricultural practices that have affected and will continue to affect floodplain wetlands and Mississippi River water quality.

In analyzing the cumulative effects of the activities discussed above, the Corps must compare the impacts to the historical, non-disturbed, Mississippi River and not compare the impacts to the current condition of the river. This includes both the historic ecological condition and the historical flow and flood level conditions. If this information is not currently available, the Corps must obtain this information unless the costs of doing so would be "exorbitant." 40 C.F.R. § 1502.22. To establish the proper baseline, the Phase V EA should document and evaluate the historical changes in the Mississippi River with respect to at least the following indicators:

- Historical flows and flood levels;
- Acres of river and floodplain wetlands lost;
- Acres of native upland habitats lost;
- Miles of streambed lost or modified;
- Changes in stream flows;
- Changes in ground water elevations;
- Changes in the concentrations of indicator water quality constituents;
- Changes in the abundance, distribution, and diversity of indicator fish, waterfowl, bird, mammal, reptile, amphibian, and mussel communities;
- Changes in rainfall, and reasonably foreseeable future changes.

(b) Cumulative Impacts of Climate Change

The National Wildlife Federation appreciates the Corps' recognition of the need to address the cumulative impacts of climate change and the discussion that has been included in the Phase V EA. However, NWF disagrees with the Corps' conclusion that climate change will not have any additive or magnifying effects on the impacts of the proposed Phase V projects. *See* EA at 24 (the basic functionality and ability of river training structures "should not be affected going forward" and "river training structures would not contribute any increase to potential future flood events.")

The National Wildlife Federation urges the Corps to expand its climate change assessment and reassess the climate change conclusions in the Phase V EA. Notably, climate change could significantly exacerbate the public safety impacts of the proposed Phase V project because climate change-induced variability in the Upper Mississippi River Basin will likely lead to more extreme weather and higher flows than have been experienced in the past. In addition, climate change could magnify the fish and wildlife impacts of the project, particularly for endangered species and migratory species that utilize the project area. Increased floods and storms caused by climate change could also affect the ability of the proposed river training structures to achieve their stated purposes, calling into question the value of construction even for navigation.

The National Wildlife Federation urges the Corps to carefully assess and/or reassess the following materials in connection with its cumulative impact analysis:

- The Midwest regional inputs to the National Climate Assessment.[26]

- The 2013 Regional Climate Trends and Scenarios for the Midwest U.S. showing that for the Midwest region, annual and summer trends for precipitation in the 20th century are upward and statistically significant; the frequency and intensity of extreme precipitation in the region has increased, as indicated by multiple metrics; and models predict increases in the number of wet days (defined as precipitation exceeding 1 inch) for the entire Midwest region, with increases of up to 60%.[27]

- The 2009 U.S. Global Change Research Program report showing that the Midwest experienced a 31% increase in very heavy precipitation events (defined as the heaviest 1% of all daily events) between 1958 and 2007.[28] That study also reports that during the past 50 years, "the greatest increases in heavy precipitation occurred in the Northeast and the Midwest." [29] Models predict that heavy downfalls will continue to increase:

> Climate models project continued increases in the heaviest downpours during this century, while the lightest precipitation is projected to decrease. Heavy downpours that are now 1-in-20-year occurrences are projected to occur about every 4 to 15 years by the end of this century, depending on location, and the intensity of heavy downpours is also expected to increase. The 1-in-20-year heavy downpour is expected to be between 10 and 25 percent heavier by the end of the century than it is now. . . . Changes in these kinds of extreme weather and climate events are among the most serious challenges to our nation in coping with a changing climate.[30]

- The March 2005 study by the U.S. Geological Survey showing upward trends in rainfall and streamflow for the Mississippi River.[31]

Climate change may also significantly exacerbate the impacts on the many migratory species that utilize the Mississippi River, Mississippi River Flyway, and the project area, and these impacts must be analyzed. As recognized by the United Nations Environment Program and the Convention on the Conservation of Migratory Species of Wild Animals, migratory wildlife is particularly vulnerable to the impacts of climate change:

[26] The Midwest regional assessment can be accessed at http://glisa.msu.edu/great_lakes_climate/nca.php (visited January 22, 2014).
[27] Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, S.D. Hilberg, M.S. Timlin, L. Stoecker, N.E. Westcott, and J.G. Dobson, 2013: Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 3. Climate of the Midwest U.S., NOAA Technical Report NESDIS 142-3, 95 pp. (available at http://scenarios.globalchange.gov/regions/midwest).
[28] Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009, at page 32 (available at http://nca2009.globalchange.gov/).
[29] *Id*.
[30] *Id*.
[31] USGS Fact Sheet 2005-3020, Trends in the Water Budget of the Mississippi River Basin, 1949-1997.

> "As a group, migratory wildlife appears to be particularly vulnerable to the impacts of Climate Change because it uses multiple habitats and sites and use a wide range of resources at different points of their migratory cycle. They are also subject to a wide range of physical conditions and often rely on predictable weather patterns, such as winds and ocean currents, which might change under the influence of Climate Change. Finally, they face a wide range of biological influences, such as predators, competitors and diseases that could be affected by Climate Change. While some of this is also true for more sedentary species, migrants have the potential to be affected by Climate Change not only on their breeding and non-breeding grounds but also while on migration."
>
> "Apart from such direct impacts, factors that affect the migratory journey itself may affect other parts of a species' life cycle. Changes in the timing of migration may affect breeding or hibernation, for example if a species has to take longer than normal on migration, due to changes in conditions *en route*, then it may arrive late, obtain poorer quality breeding resources (such as territory) and be less productive as a result. If migration consumes more resources than normal, then individuals may have fewer resources to put into breeding . . . ."
>
> * * *
>
> "Key factors that are likely to affect all species, regardless of migratory tendency, are changes in prey distributions and changes or loss of habitat. Changes in prey may occur in terms of their distributions or in timing. The latter may occur though differential changes in developmental rates and can lead to a mismatch in timing between predators and prey ("phenological disjunction"). Changes in habitat quality (leading ultimately to habitat loss) may be important for migratory species that need a coherent network of sites to facilitate their migratory journeys. Habitat quality is especially important on staging or stop-over sites, as individuals need to consume large amounts of resource rapidly to continue their onward journey. Such high quality sites may [be] crucial to allow migrants to cross large ecological barriers, such as oceans or deserts."[32]

Migratory birds are at particular risk from climate change. Migratory birds are affected by changes in water regime, mismatches with food supply, sea level rise, and habitat shifts, changes in prey range, and increased storm frequency.[33]

The Phase V EA must carefully consider whether the impacts of climate change could exacerbate the impacts of the proposed Phase V project.

[32] UNEP/CMS Secretariat, Bonn, Germany, *Migratory Species and Climate Change: Impacts of a Changing Environment on Wild Animals* (2006) at 40-41 (available at http://www.cms.int/publications/pdf/CMS_CimateChange.pdf).
[33] *Id*. at 42-43.

E. The Phase V EA Fails to Properly Evaluate Mitigation Needs

Because the Phase V EA fails to adequately evaluate project impacts, it also fails to adequately evaluate whether compensatory mitigation is required. It is virtually inconceivable that burying three quarters of a mile of river under 165,100 tons of rock would not cause adverse impacts to fish and wildlife resources that must be mitigated.

As a matter of law, the Phase V EA must include "a specific plan to mitigate for damages to ecological resources, including terrestrial and aquatic resources, and fish and wildlife losses created" by the proposed project unless the Secretary of the Army makes a determination that the project will have "negligible" adverse impacts. 33 U.S.C. § 2283(d).

F. The Clean Water Act Section 404(b)(1) Evaluation Fails to Provide an Accurate Assessment

The many failings in the Phase V EA have resulted in a Clean Water Act Section 404(b)(1) Evaluation that fails to provide an accurate and supportable assessment of the impacts of the proposed project.

G. Conclusion

For at least the reasons set forth in these comments, the Phase V EA is legally deficient and cannot be relied upon to satisfy the requirements of NEPA for the proposed project. The National Wildlife Federation urges the Corps to withdraw the Phase V EA and put the project on hold at least until the Corps completes a legally adequate supplemental environmental impact statement for the Regulating Works Program.

Sincerely,

Melissa Samet
Senior Water Resources Counsel

Attachments

Attachment A

Comments of the National Wildlife Federation

Evaluation of the Micromodel: An Extremely Small-Scale Movable Bed Model

Stephen T. Maynord, A.M.ASCE[1]

Abstract: The micromodel is an extremely small physical river model having a movable bed, varying discharge, and numerous innovations to achieve quick answers to river engineering problems. In addition to its size being as small as 4 cm in channel width, the vertical scale distortion up to 20, Froude number exaggeration up to 3.7, and no correspondence of stage in model and prototype, place the micromodel in a category by itself. The writer was assigned to evaluate the micromodel's capabilities and limitations to ensure proper application. A portion of this evaluation documents the deviation of the micromodel from similarity considerations used in previous movable bed models. The primary basis for this evaluation is the comparison of the micromodel to the prototype. The writer looked for comparisons that had (1) a reasonable calibration of the micromodel and (2) about the same river engineering structures constructed in the prototype that were tested in the micromodel and (3) a prediction by the micromodel of the approximate trends in the prototype. Evaluation of these comparisons shows a lack of predictive capability by the micromodel. Differences in micromodel and prototype likely result from uncertainty in prototype data and the large relaxations in similitude. Based on the lack of predictive evidence, the micromodel should be limited to demonstration, education, and communication for which it has been useful and should be of value to the profession.

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CE Database subject headings: Scale models; Channel flow; Sediment; River beds; Water discharge.

Introduction

The micromodel is an extremely small physical river model having a movable bed and varying discharge. It was developed in 1994 by the St. Louis District (Davinroy 1994) of the U.S. Army Corps of Engineers (USACE). Horizontal scales of up to 1:20,000 result in micromodel channel widths as small as 4 cm. Previous Mississippi River micromodels typically reproduced about 20 km of the river on the standard 1.9-m-long micromodel table. The micromodel has been used to predict the bathymetry and flow pattern trends for proposed river training structures for purposes of navigation and environmental effects. To date, over 20 reports have been published detailing micromodel studies. The writer was assigned to a USACE team in 1999 to evaluate the capabilities and limitations of the micromodel. The two other members of the evaluation team were developers and present users of the micromodel. The team could not reach a consensus on the capabilities of the micromodel and the USACE had the USACE Committee on Channel Stabilization (CCS) provide an evaluation of the micromodel based on a meeting with the team members. The CCS (USACE 2004) report concluded that the micromodel is not a detailed design tool but that the micromodel can be used for screening alternatives except for study types where human life or the overall project are at risk. For such critical study types, the CCS concluded micromodel use should be "limited." The CCS report states that "During the discussions, it became apparent to some that there is a considerable gap between the pure academic/scientific views of the micromodel technology and the practical use of the micromodel as a tool in an overall river engineering process which has been used on large rivers in MVD (Mississippi Valley Division of the USACE)." The inability to resolve the issue of whether to evaluate the river engineering process that uses a micromodel, or only the micromodel, was a major impediment to the evaluation. The proper evaluation parameter for the river engineering process is whether the project was a success. The proper evaluation parameter for the micromodel is comparison of bathymetric and flow features to the prototype. This writer is evaluating one component of the river engineering process, the micromodel, and whether it can approximately predict the bathymetric and flow features of a large river like the Mississippi.

Some observers of micromodel technology have been critical of its use. Falvey (1999) stated "*Civil Engineering* and the St. Louis District are doing the profession a disservice by implying that a micro-model is a tool that can be used for serious engineering investigations." Yalin, an expert in movable bed modeling, was able to observe and discuss the micromodel with the evaluation team. Yalin stated in a letter to this writer, "I regret that such a 'model' cannot be used for predictive purposes." Both criticisms were almost certainly the result of the micromodel's small size and lack of adherence to similarity principles used in movable bed modeling. From early in the team evaluation, this writer felt that if the size and similarity issues were significant, their effects would be seen in attempts to use the micromodel to predict response in the river. For that reason, this writer spent a large portion of the multiyear study evaluating micromodel-prototype comparisons, particularly predictions.

The objective of this paper is to present results of an evaluation funded by the USACE Research and Development Program

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Note. Discussion open until September 1, 2006. Separate discussions must be submitted for individual papers. To extend the closing date by one month, a written request must be filed with the ASCE Managing Editor. The manuscript for this paper was submitted for review and possible publication on October 18, 2004; approved on February 3, 2005. This paper is part of the ***Journal of Hydraulic Engineering***, Vol. 132, No. 4, April 1, 2006. ©ASCE, ISSN 0733-9429/2006/4-343–353/$25.00.

to determine the capabilities and limitations of the micromodel. Specific focus is directed at critical study types where human life or the overall project is at risk if the model is not correct.

Movable Bed Modeling

Yalin (1971) states that a model can be scientifically valid only if measured quantities in the model are related to their counterparts in the prototype by scale ratios that satisfy the criteria of similarity. Ettema (2001) presents the dimensionless parameters associated with flow of water and sediment in channels with a bed of cohesionless particles including movable bed models (MBMs) as

$$\Pi_A = f_A\left[D\left(\frac{g(\rho_s-\rho)}{\rho\nu^2}\right)^{1/3}, \frac{\rho Ri}{D(\rho_s-\rho)}, \frac{\rho_s}{\rho}, \frac{D}{R}, \frac{B}{R}, \frac{\sigma}{\rho g i R^2}\right] \quad (1)$$

where the dependent variable A in Π_A might be flow resistance, thalweg sinuosity, sediment transport, or some other variable in alluvial channels; D=particle size; g=gravity; ρ_s=particle density; ρ=water density; ν=kinematic viscosity of water; R=hydraulic radius; i=slope; B=channel width; and σ=surface tension. Scale distortions arise when the dimensionless parameters on the right side of the equation are not the same in model and prototype. However, some of the dimensionless ratios, under certain conditions, do not cause significant effects when model and prototype values differ. For example, in a model of sufficient size, the last parameter on the right side of Eq. (1) will not be the same in model and prototype but the effects of differences in surface tension in model and prototype will be negligible. It remains to be determined if the surface tension term can be neglected in a micromodel. The first term on the right hand side is a particle density term which shows that if a lightweight bed material is used, the particle size in the model will be larger than in the prototype. The second term is the Shields parameter that is present in almost all movable bed model criteria and defines the amount of movement of sediment. The third term (ρ_s/ρ) is often ignored because density effects are addressed in the first and second terms of the right side of the equation. The fourth term on the right hand side, D/R, is the relative roughness that is rarely equal in model and prototype of sand bed streams and is often assumed to have negligible effects on model results. However, Ettema et al. (1998) have shown significant scale effects of D/R on bridge pier scour. The fifth term on the right side is the aspect ratio that is another term that can rarely be maintained the same in MBM and prototype of sand bed rivers.

Three techniques have been used in MBM (and are used in the micromodel) to increase model Reynolds number and sediment mobility in the model and, in some MBMs, to achieve equal Shields parameter in model and prototype. In the Shields parameter, the water density ρ is fixed, prototype sediment density ρ_s is relatively constant, and the model particle size D cannot be scaled down due to particle cohesion problems and will be roughly the same in model and prototype when dealing with sand bed alluvial streams. Therefore, if the model Shields parameter is to be increased or made equal to the prototype, the only parameters that can be varied in the model are ρ_s, R, and i. Adjustment of these three parameters has led to three techniques often used jointly in MBMs as follows.

1. *Lightweight sediment*. Minimum specific gravity of MBM sediment has been about 1.05 but sediment this light has to be carefully handled and model flooding and startup are difficult. Walnut shells having a specific gravity of 1.3 have been used. Coal having a specific gravity of 1.3 is common. A wide range of plastics are available. ASCE (2000) describes some of the various sediment types used in MBM.
2. *Vertical scale distortion*. Vertical scale distortion is the second technique used to achieve correct sediment movement. Vertical scale distortion results in attempting to model a prototype channel with a model that has an aspect ratio (width/depth) that is less than the prototype. Jaeggi (1986) concludes that morphological processes are highly dependent on the aspect ratio and that a distorted model should be avoided. Glazik (1984) stated that distortion should be avoided in movable bed river models but that a value of 1.5 (ratio of model horizontal scale to vertical scale) provided adequate results. Suga (1973) reports that distortions used in his laboratory's MBM studies were 5 or less and concludes that distortion should not be used when scour depth and location are the main subjects. Foster (1975) presented cross section plots of velocity from a model with a distortion of 3 and an undistorted model of the St. Lawrence River. Foster concluded "The velocities in the distorted model shifted several hundred feet (prototype) toward the outside of the bend from those in the undistorted model." Channel width in this reach was 360–460 m (1,200–1,500 ft). Zimmerman and Kennedy (1978) conducted research on curved channels to determine the transverse bed slope in bends and concluded distorted models can be used if distortion is limited to no more than 2 or 3. ASCE (2000) suggests a limit of 6. While these previous studies consider distortion to be a necessary evil and have recommended limitations, application of regime theory to MBM requires distortion.
3. *Increased model slope*. Increased model slope is the third technique used to achieve correct sediment movement. This leads to a Froude number in the model that is greater than that of the prototype, which then raises concerns about the ability of the model to reproduce flow patterns. Einstein and Chien (1955) allow some exaggeration of model Froude number but do not recommend a limit. In an example presented by Gujar (1981), a Froude number exaggeration of $\mathsf{F}_m/\mathsf{F}_p$=2.5 was classified as large whereas 1.67 was classified as acceptable. Latteux (1986) reported that a Froude number exaggeration of 2.5 was unsatisfactory but 2.2 provided acceptable results. Vollmers (1986) used Froude number exaggeration of 1.4 in the MBM of the Elbe estuary, which had a vertical scale distortion of 8. Froude number exaggeration is based on the concept that the Froude number has limited significance for low values typical of alluvial streams. A problem arises when the Froude number is exaggerated to the point where it is no longer insignificant in the model.

Calibration versus Validation and Base Test

The terms calibration and validation must be defined as used herein. Based on ASCE (2000), "Model calibration is the tuning of the model to reproduce a single known event. Tuning the model to reproduce the prototype behavior in this event does not ensure that the model will reproduce different or future events. However, if the model cannot reproduce a known event, little confidence can be maintained that the model will reproduce future events." Vernon-Harcourt [in Freeman (1929)] used the validation concept in which he calibrated his model until it reproduced a known prototype condition. He then tested the model against a different set of prototype boundary conditions (validation) to see if it could reproduce these known changes. If satisfactory in the validation, Vernon-Harcourt then declared the model ready for prediction. The same validation concept is used herein to evaluate predictive/screening capability of the micromodel.

The micromodel uses the concept of a base test in which the calibrated model is run with a hydrograph and the resulting bathymetry and flow patterns are referred to as the base test. All plans/project alternatives are run with the same base test hydrograph and all plan results are compared to the base test results. Changes from base test results to plan results are assumed indicative of what changes will occur in the prototype. The use of a base test may reduce the required accuracy of the model somewhat but there should be some resemblance of model predictions to what occurs in the prototype.

Types of Physical Movable Bed Models

Graf (1971) categorizes MBMs as rational models that are semiquantitative and empirical models that are qualitative. The Graf categories generally correspond to the degree to which the Eq. (1) parameters are equal in model and prototype.

Rational Movable Bed Models

Graf (1971) credits Einstein and Chien (1955) with development of the rational method of MBMs. Yalin (1965) and de Vries and van der Zwaard (1975) also developed methods that fall under Graf's category of a rational MBM. The rational method is simply a more rigorous adherence to the similarity criteria in Eq. (1) and generally requires large models to apply the method. Rational models are characterized by low vertical scale distortion, low Froude number exaggeration, and equality of Shields parameters in model and prototype.

Empirical Movable Bed Models

Graf's second category, empirical MBMs, places less reliance on similarity requirements and allows greater relaxation of the Eq. (1) parameters. Warnock (1949) states, "Instead of arranging the various hydraulic forces involved to meet definite requirements laid down in any law of similitude, the successful prosecution of a movable-bed model study requires that the combined action of the hydraulic forces bring about similitude with respect to the all-important phenomenon of bed movement, which is the essence of this type of model study." Although less rigorous than the rational MBM, most empirical models attempt to limit vertical scale distortion and Froude number exaggeration. Empirical MBMs have a Shields parameter that is generally less than the prototype that is required in order to limit model size, vertical scale distortion, and Froude number exaggeration. Empirical MBMs previously used at the Engineering Research and Development Center (ERDC, formerly Waterways Experiment Station) employed coal as the model bed material and had a model Shields parameter of less than 0.1, whereas the prototypes being studied had Shields parameters in excess of 1. Glazik and Schinke (1986) describe MBM experience using a model Shields parameter significantly less than the prototype. Due to the importance of the equality of the Shields parameter in the model and prototype, empirical models are generally limited to assessing bathymetric response.

Other Movable Bed Models

Some MBMs do not fit into the two categories delineated by Graf (1971). Freeman (1929) discusses early studies by Reynolds and Vernon-Harcourt, which were similar to the empirical model but used Froude scale velocities and simulated water levels in models with large vertical scale distortions. Reynolds conducted a study of the Mersey estuary in England in a model with a vertical distortion of 27.

Pertinent Features of the Micromodel

Micromodel Description and Operation

Gaines and Maynord (2001) provide details of the design and operation of the micromodel and only a brief summary is presented herein. Past micromodel studies have selected horizontal scales so that the modeled reach will fit on a standard 0.9-m-wide by 1.9-m-long flume table that is equipped with a recirculating pump, sump, and regulating valves. Sediment is recirculated in the micromodel. Horizontal scales range up to 1:20,000 and minimum model channel widths of 4 cm are employed in the main channel and lesser model widths in side channels or tributaries. The model banks are cut vertically and the channel is filled with granular plastic that ranges in size from 0.25 to 1.2 mm and has a specific gravity of 1.48. Some recent experiments have explored using lower density model sediment. The downstream end of the channel has a fixed free overfall. Islands are simulated with solid boundaries and vertical banks in the model. After having problems of exaggerated scour with solid river training structures typically found in MBMs, river training structures in the micromodel such as dikes or bendway weirs are represented by pervious steel mesh having 3×3 mm^2 openings. A typical micromodel is shown in Fig. 1.

In the calibration process, the micromodel bed is not premolded to a specific bed condition as done in other types of MBMs. Calibration of the model begins with selection of the high and low flow used to simulate the effects of the variable hydrograph in the prototype. High flow is based on a visual assessment of both the amount of sediment movement and the energy level in the model. Low flow is based on the model producing a slight amount of sediment movement. Model hydrograph cycle times have ranged from 1.8 to 6 min with 3 to 5 min being typical. To assess whether the model is calibrated, the model is run for numerous hydrograph cycles until the bed reaches equilibrium. The model is surveyed using an innovative laser profiler and the model bathymetry is compared to the trends of available prototype surveys. If the trends are replicated in the model, the model is declared calibrated and ready for screening alternatives. If the trends are not replicated in the model, adjustments are made to one or more of the following: (1) flume table slope; (2) amount of sediment in the model; (3) size, shape, and elevation of the fixed free overfall at the downstream end; (4) inflow baffling; (5) discharge hydrograph; and (6) vertical scale and datum. Various vertical scales and vertical datum are used to convert model bathymetry to corresponding prototype numbers throughout the calibration process to achieve the best agreement of model and prototype bathymetry.

Micromodel Contrasted with Previous Movable Bed Models

Of the two Graf (1971) categories, the micromodel is closest to the empirical MBM category. While similarity laws are not fol-

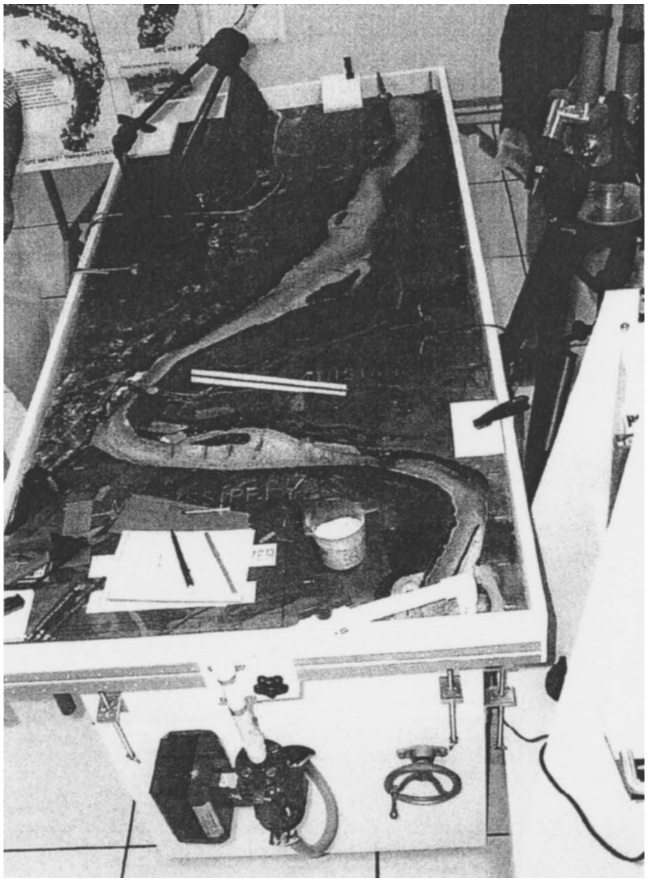

Fig. 1. Micromodel of Vicksburg Front, Mississippi River. Micromodel scale=1:14,400 horizontal, 1:1,200 vertical.

lowed closely in empirical MBMs, there are definite differences between the micromodel and most previous empirical models as follows.

1. Small size. The micromodel is one to two orders of magnitude smaller than most empirical models. Model channel widths are as low as 4 cm. Model channel depths as low as 1 cm are an order of magnitude less than the minimum of 10 cm recommended in Gujar (1981). No requirements for minimum Reynolds number are used in the micromodel. The small model depths result in large distortion of relative roughness.
2. Large vertical scale distortion. With a few exceptions, distortion ratios used in the micromodel are at least twice that in most empirical models. Micromodels commonly use distortions of 8 to 15.
3. No correspondence of stage in micromodel and prototype. Most empirical models relate stage to a corresponding stage in the prototype.
4. Low stages run in micromodel. Typical alluvial streams have dominant or channel forming discharges that are roughly at a bank-full stage. Maximum stages in the micromodel are about 2/3 of bank full.
5. Calibration of micromodel based on equilibrium bed. Previous MBMs conduct calibration by starting with a known bed configuration, running representations of the subsequent stage and discharge hydrographs, and comparing the ending bed topography in model and prototype (Franco 1978). The micromodel starts with an unmolded bed, runs a generic hydrograph for many repetitions until the bed reaches equilibrium, and compares the equilibrium bed to as many prototype hydrographic surveys as possible to see if the correct trends are reproduced.
6. The small size of the micromodel and the relatively heavy (heavy for plastic) bed material (specific gravity 1.48) results in steep slopes in the micromodel. Water-surface slopes of the few micromodels that have been measured are about 1%. Steep slopes result in significant exaggeration of the Froude number. Froude numbers in the two micromodel studies where appropriate measurements were taken, are 2.7 and 3.7 times the prototype Froude number.
7. Model sediment, when scaled to prototype dimensions using a typical vertical scale, is 0.6–1.2 m in diameter.
8. No similarity of friction in the micromodel. Even with the large exaggeration of the relative roughness, the large distortion in the micromodel results in the model being too smooth, which is typical of highly distorted models. This smoothness is possibly the reason the micromodel cannot be used to simulate high stages.
9. Micromodel uses porous dikes to solve the exaggerated scour problems around dikes that occur in distorted models.
10. Due to short duration hydrographs, no bed molding, and automated bathymetry measurement, the micromodel can evaluate an enormous number of conditions in a short period of time.

The most significant differences in the micromodel compared to empirical models are small size, large vertical scale distortion, large Froude number/slope distortion, and no correspondence of stages. These differences place the micromodel in the third category of "other" in addition to rational and empirical models. Rational models are designed and operated with similarity considerations and only small deviations are allowed. Empirical models often do not follow similarity criteria, but the manner in which they are operated results in the existence of significant but limited deviations from similarity criteria. In like manner, the operation of micromodels results in even larger departures from similarity criteria.

Proposed Uses of the Micromodel

The categorization of micromodel and other MBM capabilities can be dealt with in a variety of ways. One option is to categorize based on structure type such as bendway weirs versus traditional dikes. Another option is to categorize based on problem type such as minimization of maintenance dredging in the main navigation channel versus rehabilitation of side channels for environmental enhancement. Ettema (2001) differentiates MBMs based on the degree of freedom of lateral movement, with micromodels of a long constriction having a greater chance of success than those in which lateral movement of the thalweg is relatively unrestricted. The categorization adopted herein is based on the categorization developed in CCS (ASCE 2004) as follows.

1. Demonstration, education, and communication. This includes demonstration of river engineering concepts including the generic effects of structures placed in the river.
2. Screening tool for alternatives to reduce maintenance and dredging of the navigation channel. Failure to perform as predicted would not be damaging to the overall project or endanger human life.
3. Screening tool for alternatives of channel and navigation alignments. This category does not include navigable bridge approaches. Failure to perform as predicted would not be

damaging to the overall project or endanger human life.

4. Screening tool for environmental evaluation of river modifications, side channel modifications, notches in dikes, etc. Failure to perform as predicted would not be damaging to the overall project or endanger human life.
5. Screening tool for major navigation problems, around structures such as lock approaches, bridge approaches, confluences, etc. Failure to perform as predicted could be damaging to the overall project or endanger human life.

For category 1, the micromodel has proven to be useful and beneficial as a demonstration, education, and communication tool, and the developers have presented a valuable tool to the profession. Many of the benefits of the micromodel to the river engineering process have been a result of its value in demonstration, education, and communication. The micromodel has allowed diverse groups to reach a consensus on controversial projects. All parties in this evaluation agreed that the micromodel is effective for demonstration, education, and communication. A demonstration tool shows the generic effects of a river training structure such as traditional contracting dike causing a shoaling area to reduce or a redirection of the currents and no specific dimensions are attached to the dike characteristics or the observations from the micromodel.

Categories 2–5 require greater capability than a demonstration tool. Any conclusions about the screening capabilities of the micromodel should answer the following three questions: (1) What is a screening tool? (2) What does it take to show any model is a screening tool? (3) What facts show the micromodel is a screening tool? A screening tool is able to identify likely or unlikely solutions or rank/compare alternatives. Screening tools are used to discard some alternatives and select others for further study. Some view a screening tool as quantitative relative to model inputs like dike length, elevation, location, orientation, etc. Others view a screening tool as completely qualitative with model inputs such as dike characteristics having little or no quantitative significance. A screening tool does not always predict the correct trends but should be correct some or most of the time. A screening tool is different from a demonstration tool because it crosses the threshold between nonprediction and prediction or, stated otherwise, the threshold between telling the user information he/she might not have known. To show that any model is a screening tool requires a modest record of an approximate prediction of trends that occurred in the prototype.

The CCS concluded that screening in categories 2–4 can be based on analysis of both bathymetry and surface flow patterns but screening for category 5 can only be based on bathymetry because surface flow patterns are not considered adequate for category 5 problems. This CCS criterion is a major limitation for category 5 problems because this writer has not seen a category 5 problem that could be addressed without analysis of surface flow patterns.

Model/Prototype Comparisons

General

The previous discussion shows that the micromodel is operated with large differences from similarity principles. The remaining question is whether these differences are significant. This writer presents model-prototype comparisons to address this question of significance. Although the primary question is whether the micromodel can predict prototype response in a calibrated model, the

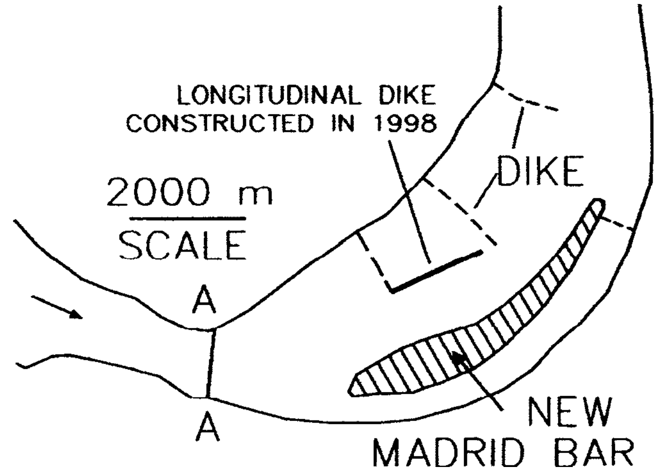

Fig. 2. Schematic of New Madrid, Mississippi River. Micromodel scale = 1 : 19,000 horizontal, 1:1,200 vertical.

ability of the micromodel to be adequately calibrated, i.e. replicate existing conditions, is the only information available in many micromodel studies. The reports from previous micromodel studies were evaluated to determine the ability of the micromodel regarding both calibration and prediction but the selected comparisons focus on projects that provide insight into the predictive capabilities of the micromodel. Some of the project comparisons were selected because those projects have been cited as evidence of micromodel success. Other micromodels achieved reasonable calibrations while some did not. These other micromodels are not discussed herein because these models did not provide information on predictive capabilities and because of page limitations in this paper.

New Madrid, Mississippi River

The New Madrid, Mississippi River micromodel study (Davinroy 1996) was conducted to develop a structural solution to repetitive maintenance dredging in the main navigation channel. The calibration has large departures in depth within the problem area compared to the prototype. Fig. 2 shows the channel schematic and the location of cross section AA about one channel width upstream of New Madrid Bar. Section AA is the location of some of the structures used in alternative tests. As shown in Fig. 3, scour reached an elevation of about 21 m below the low water reference plane (LWRP) in the prototype compared to 6 m below

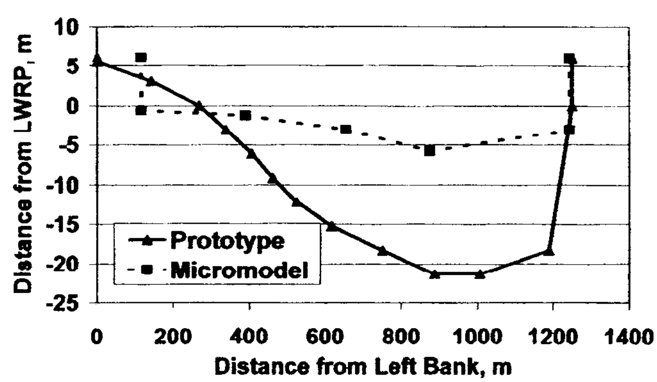

Fig. 3. Prototype and micromodel cross sections at New Madrid

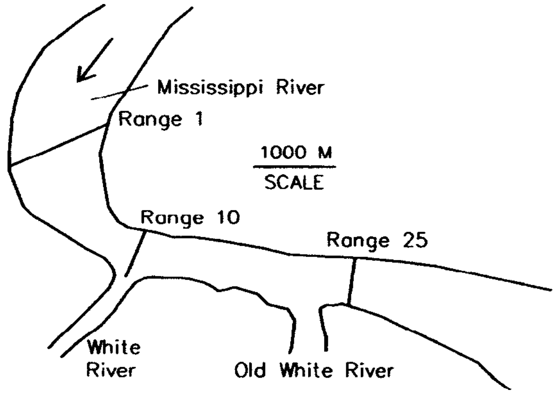

Fig. 4. Schematic of the Mouth of the White River, Mississippi River. Micromodel scale=1:12,000 horizontal, 1:1,200 vertical.

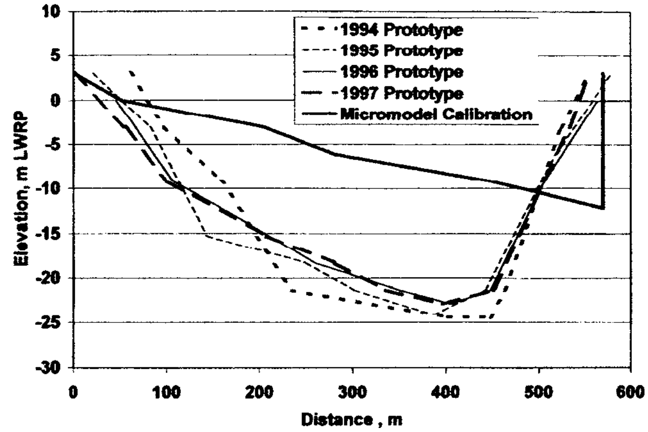

Fig. 6. Cross section at the Mouth of the White River, Range 17

the LWRP in the calibrated model. The LWRP is the stage in the Mississippi River that is exceeded about 97% of the time. The channel cross section area below LWRP=0.0 is roughly 1/3 of bank-full cross section area. The bank-full stage is about 9–10 m above the LWRP. The New Madrid study also provides information on prediction. The longitudinal dike shown in Fig. 2 was constructed in 1998. The longitudinal dike was studied in the 1996 micromodel study but was not one of the two recommended plans. The 1996 report stated that tests with a longitudinal dike indicated (1) slight channel deepening and (2) the navigation channel narrowed approximately 120 m. Subsequent prototype experience with a similar longitudinal dike in place has shown reduced dredging and an increase in the width of the navigation channel. While the project appears to be successful, the micromodel did not predict the trends of the prototype.

Mouth of the White River

The primary objective of the Mouth of the White River (MOWR) study (Gordon et al. 1998) was to evaluate design alternatives that would provide improved conditions for navigation near the MOWR (Fig. 4). The MOWR study involved navigation conditions at the confluence of two navigable rivers, the Mississippi and White Rivers. The micromodel calibration test comparison with the prototype was satisfactory upstream of the mouth, but at and downstream of the mouth, the model bathymetry differed significantly from the prototype. Fig. 5 shows the hydraulic depth (area/top width) at the LWRP along the reach. Differences in hydraulic depth in the calibration are up to 10 m at Range 19. Fig. 6 shows a cross section plot from the calibration at about Range 17 where the bed of the micromodel is up to 15 m higher than the average of 4 years of relatively consistent prototype survey data. The MOWR study is pertinent to this evaluation because (1) the micromodel procedure allows many attempts at calibration; (2) 4 years of prototype data used for calibration were relatively consistent; and (3) the best calibration was unsatisfactory. In addition to large differences in the calibration, the micromodel plan closest to the plan constructed in the prototype had top elevation of the bendway weirs at elevation −4.6 m LWRP compared to an average elevation of −7.6 m LWRP as surveyed in the prototype. The difference in calibration and in the bendway weir elevations means that the Mouth of the White River provides little information about the predictive capabilities of the micromodel.

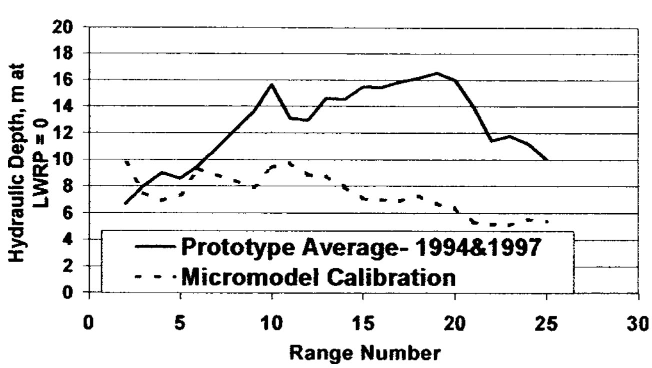

Fig. 5. Hydraulic depth at Mouth of the White River

Vicksburg Front

The Vicksburg Front comparison addresses the validity of bathymetry trends and surface currents in a calibrated micromodel and does not provide any information on prediction/validation. Maynord (2002) presents results of a comparison of surface currents in the Vicksburg Front micromodel and the prototype. Confetti streaks and particle image velocimetry (PIV) were used to determine surface velocities in the Vicksburg Front micromodel. Recording global positioning system (GPS) units used in differential mode were placed on surface floats in the bend of the Mississippi River at Vicksburg, Mississippi. The GPS floats were placed at various locations across the channel upstream of the bend at Vicksburg and retrieved at the lower end of the bend. The average stage in the river during the 4-day measurement period and the stage in the micromodel were almost identical. Fig. 7 shows a schematic of the Vicksburg bend and the location of a cross section at river mile 439.5 where velocities were compared from the GPS prototype and the PIV micromodel. Fig. 8 shows the cross section velocity plot from the micromodel and prototype. Velocities in the micromodel were converted to prototype using the square root of the vertical scale ratio that is the ratio typically applicable to distorted models. The plot shows the exaggeration of velocity that is typical of MBMs. In this case the exaggeration is large, about 3.7 times the Froude scale velocities. The plot also shows velocities in the micromodel are concentrated on the left descending bankline when compared to the prototype data. The concentration of flow on the left bank in the

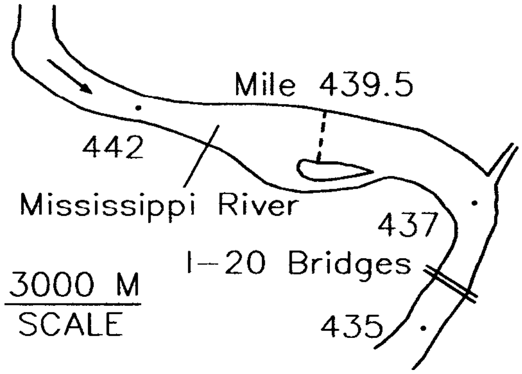

Fig. 7. Schematic of Vicksburg Front, Mississippi River. Micromodel scale=1:14,400 horizontal, 1:1,200 vertical.

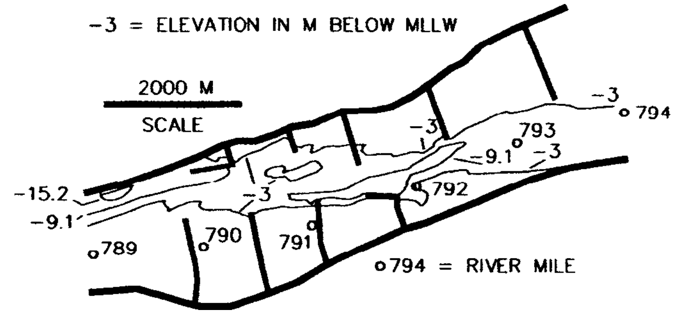

Fig. 9. Kate Aubrey, Mississippi River, 1998 prototype bathymetry. Flow from right to left.

micromodel is consistent with the incorrect sediment deposition in the micromodel along the right bank at river mile 437.5 that does not occur in the prototype.

Kate Aubrey

The Kate Aubrey reach of the Mississippi River has experienced shoaling problems that required repeated dredging. Two micromodels of the Kate Aubrey reach were constructed as part of the USACE micromodel evaluation to validate or test predictive capability. The Kate Aubrey models were a major component of the team evaluation. The two micromodels included a traditional size micromodel having a 1:16,000 horizontal scale and 1:900 vertical scale and a larger (2×) micromodel having a 1:8,000 horizontal scale and 1:600 vertical scale. Both micromodels were calibrated to 1975 and 1976 bathymetry. The predicted micromodel bathymetry was compared to the 1998 bathymetry (Fig. 9) and was not similar to the prototype in both the 1:8,000 (Fig. 10) and 1:16,000 (Fig. 11) micromodels. The problem area is centered at about mile 791–792. Extensive dredging was conducted in this reach in 1988 and may have contributed to some of the differences between model and prototype. However, the high flows during the mid-1990s would likely minimize the effects of dredging ten years earlier in 1988 and the dredging impacts would not show up in the 1998 bathymetry. The Kate Aubrey comparisons leads to the conclusion that a micromodel can be calibrated yet not be validated and thus, cannot be used for prediction of alternative effects.

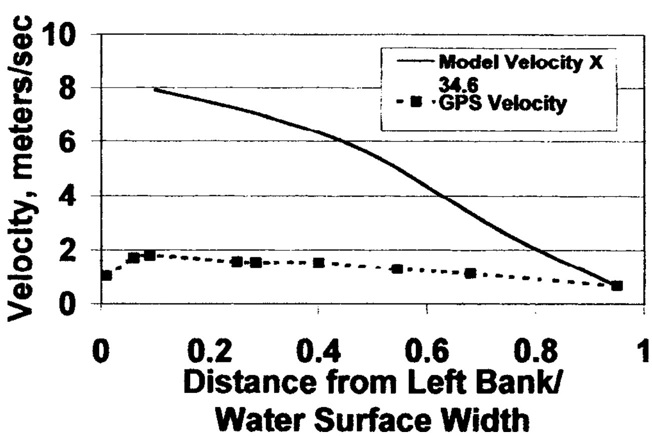

Fig. 8. Prototype GPS and micromodel velocities at Vicksburg Front

Bolter's Bar

The Bolter's Bar micromodel study was conducted to evaluate alternatives to alleviate dredging in the main channel without adversely affecting side channels. A schematic of the reach with the dikes that were present in 1997–1998 is shown in Fig. 12. The dredging problem was primarily between river miles 225 and 226. Fig. 13 shows the plan constructed in the prototype in 2002 that includes four chevron dikes on the right side of the navigation channel between river miles 225 and 226, a longitudinal dike on the right bank at river mile 226, and raising and notching the existing closure dike. The four left bank dikes between river miles 226 and 225.4 were removed from the micromodel but remain in the prototype. Little is known about the characteristics of the left bank dikes. The micromodelers have stated they believe the left bank dikes have little impact on the bathymetry. Since the 2002 construction of the improvement plan, dredging has been reduced in the reach and survey data show an improved navigation channel through the problem dredging reach. However, the difference in model and prototype because of the left bank dikes and the limited time since construction make it difficult to evaluate this validation/prediction.

Lock and Dam 24

The Lock and Dam 24 micromodel was conducted to evaluate means of reducing outdraft. Outdraft results from the cross currents in the upstream lock approach that cause a tow to move toward the dam rather than into the lock (Fig. 14). Outdraft is a dangerous condition at many locks and dams and has resulted in numerous accidents. The guardwall in the Lock and Dam 24 micromodel was solid but the guardwall in the prototype was ported which means that it has openings at the bottom to pass flow out of

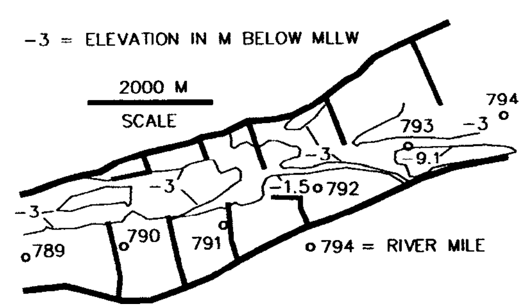

Fig. 10. Kate Aubrey, Mississippi River, 1:8,000 micromodel prediction of 1998 conditions. Flow from right to left. Upper end of model at mile 803.

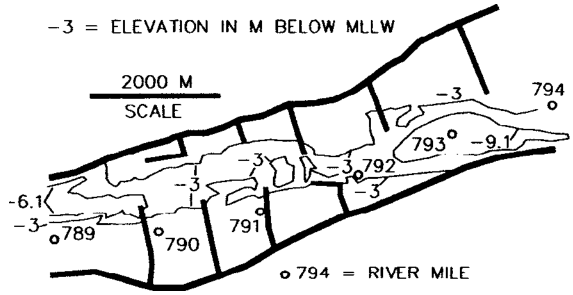

Fig. 11. Kate Aubrey, Mississippi River, 1:16,000 micromodel prediction of 1998 conditions. Flow from right to left. Upper end of model at mile 803.

the lock approach. A solid guardwall was used in the micromodel to represent a worst case and because the guardwall ports often clog with debris. The currents behind the guardwall in the prediction of the micromodel did not agree with the currents measured in the prototype. The micromodel showed slackwater just upstream of the area between the upper end of the guardwall and the bank. The prototype showed significant currents in this area. This raises two possibilities. If the ports were clogged at the time of prototype measurement, the model predicted incorrect currents. If the ports were open during prototype measurement, the difference in guardwall configuration could explain all or part of the difference in flow patterns and the Lock and Dam 24 comparison provides no information about the predictive capabilities of the micromodel.

Comparison of Micromodel and ERDC Coal Bed Models

In addition to the Kate Aubrey micromodels built and studied by the evaluation team, another major portion was an evaluation of micromodels relative to coal bed models previously used at ERDC. This component of the evaluation began with the objective of using comparison of model and prototype cross section areas, channel widths, and other bathymetric parameters to determine if a MBM was calibrated rather than using the subjective/visual comparisons that have been used traditionally. Several

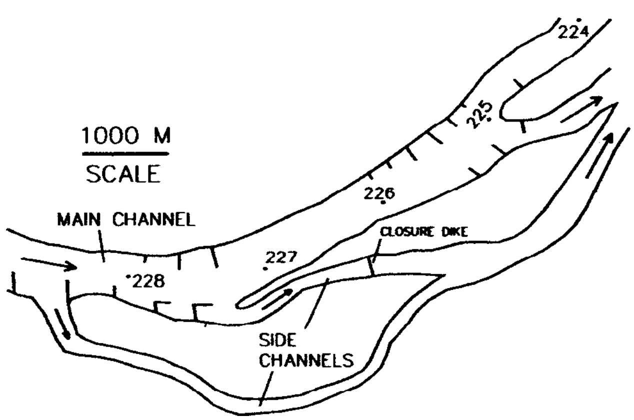

Fig. 12. Schematic of Bolter's Bar, Mississippi River, without project. Micromodel scale = 1 : 9,600 horizontal, 1:600 vertical. Upper end of model at mile 231.5.

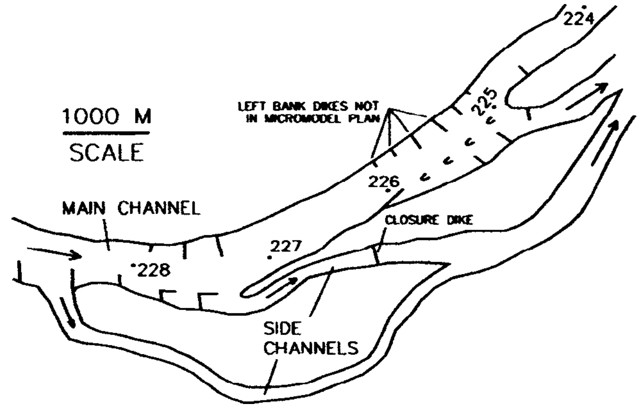

Fig. 13. Schematic of Bolter's Bar, Mississippi River, with project. Micromodel scale = 1 : 9,600 horizontal, 1:600 vertical. Upper end of model at mile 231.5.

modelers were skeptical about quantifying whether a model was calibrated.

The techniques developed for determining calibration were also used to compare the coal-bed model and the micromodel. For example, the ratio of difference in model and prototype cross section area to cross section area in the prototype was determined for each cross section. A mean squared error (MSE) measure of dispersion of the data was defined as the square of this ratio for each cross section that was averaged over the length of the model (except for entrance and exit reaches). For cross sectional area, the MSE for 16 coal bed models ranged from 0.014 to 0.33 with an overall average MSE for all models of 0.12. The MSE for area in 14 micromodels ranged from 0.024 to 0.456 with an overall average MSE for all models of 0.16. The MSE for area in the MOWR micromodel discussed previously was 0.16. An MSE of 0.16 for area means that prototype and model area differed by an average of 40% of the prototype area over the length of the model. Other bathymetric parameters used in the comparison were (1) thalweg location had overall MSE = 0.11 in the coal bed and 0.05 in the micromodel; (2) width had the same overall MSE = 0.06; and (3) hydraulic depth had overall MSE = 0.09 in the coal bed and 0.14 in the micromodel. Because of limited prototype data, the bathymetry parameters were evaluated at an elevation of 0.0 LWRP that is a low stage. Consequently, these error measures are somewhat larger than would be the case had data been available at higher stages. An LWRP of 0.0 is significant for navigation purposes because it roughly corresponds to the width

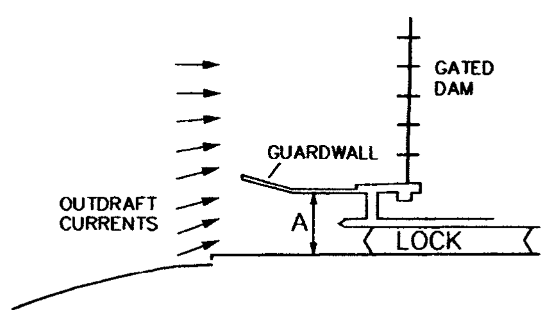

Fig. 14. Schematic of Lock 24 outdraft at upstream lock approach on Mississippi River. Micromodel scale = 1 : 9,600 horizontal, 1:600 vertical. Dimension "A" in micromodel is about 0.8 cm versus a prototype distance of about 80 m.

of the navigable portion of the channel. With the exception of one model (Kate Aubrey), the comparison micromodels were all different projects than the comparison coal-bed models. Gaines (2002) used similar geometric techniques with only the Kate Aubrey coal-bed and micromodels and concluded that "Therefore, there is no advantage in using the larger scale models (coal-bed models) to evaluate river training structures over the small-scale models (micromodels)." This writer does not place significant weight on the comparison of coal-bed models and micromodels because of the following.

1. The comparison was based on calibration only. As stated in ASCE (2000), calibration does not ensure the model will predict. As stated previously, the micromodel is significantly different from previous empirical models like the ERDC coal-bed models and equivalency based only on calibration is not valid.
2. The adjustment of vertical scale and vertical datum in the calibration process should insure that reach averaged values will be close in micromodel and prototype. To a lesser extent, this same factor is true in the coal bed model because of other adjustments.

Basis of Unsatisfactory Calibration and Validation

Why are the previous calibrations and validations (predictions) of micromodels unsatisfactory? Some of the differences can be attributed to variability and uncertainty in the prototype bathymetry data. The large relaxations in similarity criteria must also be a primary factor. Ettema and Muste (2004) conducted scale effect fixed-bed flume experiments and found that thalweg alignment and extent of separation around spur dikes do not scale with model length scale for a range of small models. Ettema and Maynord (2002) note that in hydraulic models, the usual causes of scale effects are (1) large length scales; (2) distortion of vertical scale relative to horizontal scale; (3) inflation of bed sediment size; and (4) amplification of channel slope. All of these scale effect causes are present in the micromodel as discussed previously. In addition to these four causes, the micromodel does not have correspondence of stage in model and prototype. Since all four causes plus the stage issue are present in the micromodel and there are unknown interactions, it is not possible to state which specific causes are responsible for the differences in model and prototype shown previously. At the small dimensions of flow in the micromodel, Reynolds and Weber numbers are sufficiently different than at full scale as to influence flow behavior and distribution (Ettema 2001). Froude number exaggerations up to 3.7 and vertical scale distortion up to 20 are likely causes of poor agreement of lateral velocity distribution and thus bathymetry in the model. Struiksma and Klaasen (1987) report scale effect problems resulting from exaggerations in Froude number and from bed roughness not being reproduced. Ettema (2001) and Ettema and Muste (2002) conclude that micromodels can be useful in situations where the thalweg is constrained to only vertical movement such as in a long constriction. In cases where the thalweg can move laterally, model utility diminishes quickly.

Is the Micromodel Capable of Quantitative Inputs?

Quantitative inputs describe dikes or other river engineering structures by their length, elevation, location, etc. River engineering often uses contraction of the channel to achieve a desired navigation channel. The amount of contraction of a proposed plan and thus dike characteristics cannot be specified when the water levels and thus the channel area are not modeled. The effectiveness of a dike cannot be assumed equal in model and prototype when the model velocities are roughly 2.7 to 3.7 times higher than scaling by Froude criteria. While the porous dikes used in the micromodel have some significant advantages, they have not been shown to address the problems of incorrect water level and high velocities regarding quantitative inputs.

Conclusions and Recommended Capabilities and Limitations

The micromodel, because of its small size and large deviations from similarity considerations, is different from previous MBMs and does not fit into either of Graf's categories of empirical or rational models. In addition to its size being as small as 4 cm channel width, large vertical scale distortion, large Froude number exaggeration, and no correspondence of stage in model and prototype, place the micromodel in a category by itself.

The micromodel is effective for demonstration, education, and communication and the developers have provided a valuable tool to the profession.

The disagreement over the micromodel concerns screening capability and can best be resolved by answering the following three questions: (1) What is a screening tool? (2) What does it take to show any model is a screening tool? (3) What facts show the micromodel is a screening tool? A screening tool is able to identify likely or unlikely solutions or rank/compare alternatives. A screening tool is used for prediction in order to eliminate some alternatives and keep others for further study. To show that any model is a screening tool requires a modest record of prediction of the approximate trends that occurred in the prototype. The pertinent facts regarding screening capability in the micromodel are as follows.

1. The two Kate Aubrey models provided unsatisfactory predictions of bathymetry.
2. The New Madrid micromodel predicted narrowing of navigation channel but widening occurred in the prototype. New Madrid is one of the examples of a successful project not being a successful model-prototype comparison.
3. Bolter's Bar appears to come closest to a successful prediction but the comparison has uncertainty because the left bank dikes are present in the prototype and not present in the micromodel prediction.
4. The calibrated Vicksburg Front model had velocity and sedimentation trends that did not agree with the prototype.
5. No prediction evidence is provided by the Mouth of the White River micromodel because the calibration differs greatly from the prototype and the bendway weirs have a different elevation in model and prototype.
6. Predicted model velocities did not agree with the prototype at Lock and Dam 24. Depending on whether the guardwall ports were clogged during the time of prototype measurement, the micromodel predictions were either incorrect or can be explained by the difference in micromodel and prototype ports.
7. The micromodel achieves calibration similar to coal-bed models used at ERDC based on bathymetric parameters averaged over most of the length of the model. Data were not available to evaluate prediction using these same parameters.
8. The large departures from similarity principles in the micro-

model and no correspondence of water level in the micromodel and prototype are of concern.

This writer found successful projects that had been micromodeled but looked for micromodel-prototype comparisons that had (1) a reasonable calibration; (2) about the same river engineering structures constructed in the prototype that were tested in the model; and (3) a prediction of the correct trends in the prototype. The evidence is not overwhelming (because there are relatively few studies providing information on prediction) but shows a lack of predictive capability. Based on the lack of predictive evidence, the micromodel should be limited to demonstration, education, and communication for which it is effective and useful. This conclusion differs from the CCS (ASCE 2004) report that concluded screening capability for all but category 5 problems.

Quantitative inputs have little significance in the micromodel because the water level is not correct and the velocities are 2.7 to 3.7 times greater than given by Froude scaling.

Screening for category 5 studies that are complex and where human life or the overall project are at risk such as navigation near structures, bridge approaches, and confluences is of particular importance to this evaluator. In this writer's opinion, the micromodel should not be used for category 5 problems. This conclusion is consistent with the recommendations of the CCS (ASCE 2004) for category 5 problems.

Acknowledgments

The study described herein was funded by the USACE. The views expressed herein are the writer's. Diverse views of micromodel capability exist within the USACE.

Notation

The following symbols are used in this paper:

B = channel width;
D = particle size;
F_m = Froude number in model;
F_p = Froude number in prototype;
g = gravitational acceleration;
i = slope;
R = hydraulic radius;
ν = kinematic viscosity;
ρ = water density;
ρ_s = particle density; and
σ = surface tension.

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Attachment B

Comments of the National Wildlife Federation

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IN THE UNITED STATES DISTRICT COURT
FOR THE SOUTHERN DISTRICT OF ILLINOIS

NATIONAL WILDLIFE FEDERATION, PRAIRIE RIVERS NETWORK, MISSOURI COALITION FOR THE ENVIRONMENT, RIVER ALLIANCE OF WISCONSIN, GREAT RIVERS HABITAT ALLIANCE, and MINNESOTA CONSERVATION FEDERATION, Plaintiffs, vs. UNITED STATES ARMY CORPS OF ENGINEERS; LT. GENERAL THOMAS P. BOSTICK, Commanding General and Chief of Engineers, LT. GENERAL DUKE DELUCA, Commander of the Mississippi Valley Division of the Army Corps of Engineers, Defendants.	CASE NO. 14-00590-DRH-DGW **DECLARATION OF NICHOLAS PINTER, Ph.D. IN SUPPORT OF PLAINTIFFS' MOTION FOR PRELIMINARY INJUNCTION; EXHIBITS 1-3** HEARING: TBD TIME: TBD

I, Nicholas Pinter, declare as follows:

Professional Experience and Background

1. I am a Professor in the Geology Department and Environmental Resources and Policy Program at the Southern Illinois University, and Director of the SIU's Integrative Graduate Education, Research and Training (IGERT) program in "Watershed Science and Policy." I have a Ph.D. (1992) from the University of California, Santa Barbara and an M.S. (1988) from Penn State University. I have authored, edited, or contributed to at least five books and authored over 39 peer-reviewed, published scholarly articles in rivers, flood hazard, and related fields.

2. My primary field of expertise is in earth-surface processes (geomorphology) applied to a broad range of theoretical questions and practical applications. Much of my recent work focuses on rivers, fluvial geomorphology, flood hydrology, and floodplains. This research includes field-based work, modeling, and significant public-policy involvement.

3. My lab uses hydrologic and statistical tools, 1D and 2D hydraulic modeling, and loss-estimation modeling to quantify the impacts of river and floodplain engineering, and to assess regional floodplain management strategies and mitigation solutions. My research group has also compiled a large NSF-funded GIS database of over 100 years of channel hydrography, floodplain topography, and engineering construction and infrastructure on over 2500 miles of the Mississippi and Missouri Rivers in order to empirically test the causal connections between channel and floodplain modifications and flood response. Another recent NSF-funded project assessed the impacts of progressive levee growth along the Mississippi River through hydraulic modeling of multiple calibrated time steps and multiple change conditions.

4. My research group also runs a series of FEMA-funded grants doing hazard modeling and mitigation planning across the central United States. To date, the group has completed more than 40 FEMA disaster mitigation studies, and we have a number of new plans and plan updates on-going. One principal modeling tool is the Hazus-MH package that, along with various GIS-based and modeling tools, allows estimation of disaster damages and effects for a range of hazards and disaster scenarios. This modeling capability nicely bridges the gap between pure hydrologic and hydraulic analyses (as well as site-specific earthquake studies) and broad societal impacts.

5. My Curriculum Vitae is attached hereto as Exhibit 1.

Documents Reviewed for this Declaration

6. I am familiar with the literature regarding the morphology and dynamics of the Mississippi and other rivers and the interaction between river engineering structures and floods, including the studies cited in Appendix A, Summary of Research on the Effects of River Training Structures on Flood Levels, to the Final Environmental Assessments with Finding of No Significant Impact prepared by the U.S. Army Corps of Engineers ("Corps") for the Dogtooth Bend, Monsenthein/Ivory Landing, and Eliza Point/Greenfield Bend projects, and the Draft Environmental Assessment and Unsigned Finding of No Significant Impact for the Grand Tower project.

7. I have reviewed the Environmental Assessments with Finding of No Significant Impact for the Dogtooth Bend, Monsenthein/Ivory Landing, and Eliza Point/Greenfield Bend projects, and the Draft Environmental Assessment and Unsigned Finding of No Significant Impact for the Grand Tower project.

Analysis

8. I have been asked to form an independent professional opinion as to whether building new river training structures, including those planned by the Corps in the Dogtooth Bend, Monsenthein/Ivory Landing, Eliza Point/Greenfield Bend, and Grand Tower projects, may pose a significant risk of irreparable harm to the natural environment and to people and the property of people who live, work, attend school, or recreate in the floodplains, including by raising flood stage heights on the Mississippi River. As discussed in the following analysis, I conclude that the Corps' proposed projects, and river training structures generally, do pose such a risk.

9. Damages from floods worldwide have risen dramatically over the past 100 years (Munich Re Group, 2007). While much of this increase is due to economic development in floodplains (Pinter, 2005; Pielke, 1999), it is also clear that flooding itself has physically increased in magnitude and frequency on many rivers, including the Mississippi River. (Pinter et al., 2006a; Pinter et al., 2006b; Helms et al., 2002). Historical time series of stage data, which are

unequivocally homogenous over time (Criss and Winston, 2008), show strong and statistically significant increases of flood heights on the Mississippi River over time.

10. A number of processes can lead to flood magnification or otherwise alter flood response in a river basin. These include climate change, agricultural practices, forestry practices, urbanization, road construction, construction of other impervious surfaces, loss of wetlands, decreases in floodplain storage areas, construction and operation of dams, and modifications and engineering of river channels. The range of these changes can alter the volume and timing of runoff (discharge or flow of water) entering and moving through river systems. In addition, other natural or human-induced changes to river channels and their floodplains can alter the conveyance of flow with the river channels, resulting in increases or decreases in water levels (including flood stages) for the same discharge.

11. The Mississippi River has been intensively engineered by the Corps over the past 50 to 150-plus years (depending on the reach), and some of these modifications are associated with large decreases in the river's capacity to convey flood flows. Numerous scientific investigations including Corps reports, some dating back to the 1950s, have noted large increases in flood levels in association with wing-dike construction. For example, investigators recognized as early as 1952 that "the carrying capacity of the river has been decreased so materially by the [river training] work that floods have occurred at such points as Waverly, Boonville and Hermann, Mo., at lower gauge readings with smaller volumes of water than the 1929 flood stage." (Schneiders, 1996 at 346). These investigations have prompted some agencies to rethink their river management strategies. In the Netherlands, for example, the government has begun modifying river training structures on the Rhine River to reduce this recognized risk. General Accounting Office, "Mississippi River: Actions Are Needed to Help Resolve Environmental and Flooding Concerns about the Use of River Training Structures (December 2011) ("GAO Report") at 41. To date, however, the Corps has never addressed in an EIS the vast body of peer-reviewed, independent research showing that river-training structures increase flood heights. *Id.*

12. My research has looked extensively at the extent and causes of flood magnification, particularly on the Mississippi River. This research documents that climate, land-use changes, and

river engineering have contributed to statistically significant increases in flooding along portions of the Mississippi River system. However, the most significant cause of flood height increases on the Middle Mississippi River and Lower Missouri River can be traced to the construction of wing dikes and other river training structures. Indeed, flood height increases on those river segments exceed by a factor of ten the maximum credible increases that could be expected from climate-driven and land-cover-driven flow increases (e.g., Pinter et al., 2008). The large multivariate study by Pinter et al. (2010) identified the age, location, and extent of every large levee system added to the Mississippi-Lower Missouri system during the past century, documenting that levees do contribute some but not all of the observed flood-level increases on the Middle Mississippi and elsewhere (confirming modeling by Remo et al., 2009; see Exhibit 2 to this declaration).

13. Recent theoretical analysis has shown that increased flood levels caused by wing-dike construction are "consistent with basic principles of river hydro- and morphodynamics" (Huthoff et al., 2013). This study concluded that even with extremely conservative parameters used in modeling, "the net effect of wing dikes will be higher flood levels." *Id.*

14. This theoretical analysis is supported by empirical studies that have utilized hydrologic analyses; rigorous statistics; geospatial analyses; and 1D, 2D, and 3D hydraulic modeling to confirm, empirically as well as theoretically, the potential for significant increases in flood levels in response to the dense emplacement of wing-dike structures, such as employed on the Middle Mississippi River. Among this body of research, my research group was funded by the National Science Foundation to construct two large river-related databases to rigorously test for trends in flood magnitudes over time on over 4000 kilometers (over 2400 miles) of the Mississippi and Missouri Rivers, and to quantify the impacts on flood levels from each unit of channel and floodplain infrastructure construction or other change.

15. Our hydrologic database consists of more than 8 million discharge and river stage values, including new synthetic discharges generated for 41 stage-only stations. This hydrologic database was used to test for significant trends in discharges, stages, and ''specific stages.'' We also conducted an extensive review of the validity of using discharge data taken from different types of measurement devices (float meters vs. other types of meters). Pinter (2010) tested whether

it was appropriate to utilize older discharge measurements by examining 2150 historical discharge measurements digitized from the three principal stations on the Middle Mississippi River (MMR), including 626 float-based discharges and 1516 meter-based discharges, and including 122 paired measurements. All statistical tests we performed demonstrated that it was appropriate to utilize both older historical discharge data and newer discharge data as those different types of measurement tools produced accurate discharge measurements.

16. Our geospatial database consists of the locations, emplacement dates, and physical characteristics of over 15,000 structural features constructed along the study rivers over the past 100 to 150 years. In developing this database we utilized: more than 4000 individual map and survey sheets; structure-history databases from six Corps Districts; databases from other agencies including the Coast Guard; and archival maps and surveys digitized and calibrated into a modern coordinate system and frame of reference. Within this database we parameterized 130 bridges, 54 dam structures, 25 artificial meander cut-offs, 1093 levees, and 13,231 wing-dam segments, among many other structures.

17. Together these two databases were used to generate reach-scale statistical models of hydrologic response. These models quantify changes in flood levels at each station in response to construction of wing dikes, bendway weirs, meander cutoffs, navigational dams, bridges, and other river modifications.

18. Our analyses show that while climate and other land-use changes did lead to increased flows, *the largest and most pervasive contributors to increased flooding on the Mississippi River system were wing dikes and related navigational structures*. In contrast, large reaches of the Mississippi and Missouri Rivers with little or no dike construction showed *no* significant increases in flood levels. System-wide, the hydrologic pattern was that large-scale increases in flood levels occurred when and where large numbers of dikes and dike-like structures have been built. Progressive levee construction was the second largest contributor.

19. Our analyses demonstrate that wing dikes constructed downstream of a location were associated with increases in flood height ("stage"), consistent with backwater effects upstream of these structures. Backwater effects are the rise in surface elevation of flowing water upstream

from, and as a result of, an obstruction to water flow. These backwater effects were clearly distinguishable from the effects of upstream dikes, which triggered simultaneous incision and conveyance loss at sites downstream. On the Upper Mississippi River, for example, stages increased more than four inches for each 3,281 feet of wing dike built within 20 RM (river miles) downstream. These values represent parameter estimates and associated uncertainties for relationships significant at the 95 percent confidence level in each reach-scale model. The 95-percent level indicates at least a 95% level of certainty in correlation or other statistical benchmark presented, and is considered by scientists to represent a statistically verified standard. Our study demonstrated that the presence of river training structures can cause large increases in flood stage. For example, at Dubuque, Iowa, roughly 8.7 linear miles of downstream wing dikes were constructed between 1892 and 1928, and were associated with a nearly five-foot increase in stage. In the area affected by the 2008 Upper Mississippi flood, more than six feet of the flood crest is linked to navigational and flood-control engineering.

20. More than 143 linear miles of wing dikes have been constructed on the Middle Mississippi River over the past 100 years (Remo and Pinter 2007; Remo et al. 2008). This represents about 3,960 feet of wing dikes per mile (or about 2,460 feet per kilometer) of channel. Wing dikes have also been heavily utilized on the Lower Missouri River, with over 383 linear miles constructed since 1890. This represents nearly 3,700 feet of wing dike per mile (or about 2,300 feet per kilometer) of channel in the Lower Mississippi River. These and similar river training structures are utilized to assist in river bank protection and stimulate channel scour which can reduce the amount of dredging required to maintain adequate navigation depths (e.g. COPRI 2012).

21. The effects of wing dikes and other structures during flooding should not be confused with effects during periods of low flow. There is general agreement that during low in-channel flows, wing dikes lead to lowered water levels. This happens because the dikes cause channel incision, which is a process of channel adjustment by which channel flow removes sediment from the stream bed and ultimately establishes a lower bed elevation. Channel incision is a process that has been well documented after dike construction in many (but not all) areas of the alluvial Mississippi and Missouri Rivers (e.g., Pinter and Heine 2005; Maher 1964).

22. For example, water levels at St. Louis measured during periods of low to average flows have decreased over a period of about 60 years. This decrease reflects the well documented effects of dike construction (also dredging) that has constricted the channel, eroded the channel bed, and thus lowered such non-flood water levels. Downstream at the Chester and Thebes measurement stations, water levels have also decreased during low flows, but they have risen for all conditions from average flows up to large floods. At Grand Tower, Illinois, water levels for just average flows have increased by almost three feet due to dike and weir construction. Near Grand Tower, bedrock underlies parts of the Middle Mississippi channel and limits incision (Jemberie et al. 2008). At all of these locations, *at flood flows* (flows equal to four or more times the average annual discharge level), *water levels have increased by three to ten feet or more.*

23. Many other studies confirm and corroborate these findings. Particularly after the record-breaking floods on the Middle Mississippi, researchers sought to answer why such large increases in flood levels had occurred for the same discharges (volumes of flow) that had been observed in the past. (e.g., Belt 1975; Stevens et al. 1975). Since then, multiple studies involving hydrologic time-series analyses, statistical analyses, geospatial analyses, and hydraulic modeling have correlated the timing and spatial distribution of dike construction with increases in flood stages (e.g., Criss and Shock 2001; Wasklewicz et al. 2004; Jemberie et al. 2008; Pinter et al. 2008; Remo et al. 2009; Pinter et al. 2010, and others).

24. Wing dikes and other river training structures increase flood heights during high water because of the way they interact with river flow and the way they change the shape and form of the river channel. Since the beginning of historical "training" (engineering of the river to facilitate navigation) of the Mississippi and Missouri rivers, construction of dikes has narrowed large portions of these river channels to one-half or less of their original width. In addition, construction of dikes, bendway weirs, and other in-channel navigational structures has increased the "roughness" of the channel, leading to decreased flow velocities during floods.

25. Channel roughness is a measure of objects and processes that cumulatively resist the flow of water through a given reach of a river, including drag effects of sedimentary grains, bedforms (e.g., ripples and dunes on the bed), vegetation, turbulence, eddy circulation, and many

others. A rough river bed exerts more resistance than a smooth river bed, resulting in slower flow of water. All other factors being equal, a flood that passes through a river reach with half the average flow velocity will result in average water depths that are double what they would otherwise be.

26. Recent modeling studies demonstrate the significant effects of flow turbulence and large-scale vertical and horizontal eddy circulation (Huthoff et al., 2013) of river training structures during flood events. Other recent studies have focused on flow dynamics around submerged wing dikes and their impact on channel flow resistance (e.g., Yossef 2005; Yossef and de Vriend 2011; Azinfar and Kells 2011). These studies show that submerged wing dikes create flow mixing in their wake zones (e.g., Yossef 2005; Yeo and Kang 2008; Jamieson et al. 2011). These recirculating flows consume energy from the bulk flow field, causing increases in effective resistance near wing dikes and through wing-dike fields. The impact of wing dikes on flow resistance was quantified by Yossef (2004, 2005), whose proposed relationship allows for an initial assessment of wing-dike impact on water levels (e.g., Azinfar 2010). According to Yossef's laboratory experiments, the effective cumulative hydraulic roughness of the bank zone relates to the size and longitudinal distance between the wing dikes.

27. The role of river training structures in increasing flood heights is well recognized. For example, in the Netherlands, the impacts of wing dikes (navigational "groynes") on flood levels have both been recognized and taken into account in flood protection strategies. The government of the Netherlands recently completed a €45 million program to lower 450 wing dikes (groynes) on the Rhine system as part of its strategy to reduce flood levels.

28. Changes in channel geometry and roughness related to river engineering tools employed for improved navigation and flood control are the principal drivers behind changes in flood stage on the Mississippi River. The increases in flood stage are caused by both the direct effects of wing dikes, meaning interaction with flow, and the indirect effects of wing dikes, meaning the effects of the wing dike in changing the shape or form of the river bed. Hydrodynamic simulations of indirect and direct effects of wing dikes show decreases in velocity, increases in roughness, and corresponding increases in flood stage.

29. River training structures constructed by the Corps to help maintain the nine-foot navigation channel have caused large-scale increases in flood levels, up to 15 feet in some locations and by some measures, and six to ten feet over broad stretches of the river where these structures are prevalent. Such large increases in flood heights in these rivers have occurred when and where – and only when and where – wing dikes, bendway weirs, and other river training structures have been built. These structures have led to significant increases in the frequency and magnitude of large floods.

30. The projects now proposed on the Middle Mississippi River are particularly problematic for several reasons. First, as mentioned above, bedrock underlies parts of the Middle Mississippi channel near the Grand Tower project, which limits incision (Jemberie et al. 2008). In such locations, the ameliorating effect of new wing dikes in causing bed incision is reduced or eliminated, leading in the past to the largest observed increases in flood levels.

31. The new dike construction projects now proposed on the Middle Mississippi are also problematic because they threaten nearby levees that already have identified deficiencies. The Dogtooth Bend Project is immediately downstream of one of the sites where the Len Small levee failed during floods in 2011 (Dogtooth Bend EA at E2). This 5,000-foot breach yielded to fast-moving water that "scored farmland, deposited sediment, and created gullies and a crater lake" (K.R. Olson and L.W. Morton, "Impacts of 2011 Len Small levee breach on private and public Illinois lands," *Journal of Soil and Water Conservation*, Vol. 68:4, attached as Exhibit 3).

32. The proposed Grand Tower project spans approximately seven River Miles along the Big Five Levee Drainage and Levee Districts, including the Preston, Clear Creek, East Cape, and Miller Pond levees, together protecting over 49,000 acres of Illinois floodplain. The proposed Grand Tower wing dike project also lies just downstream of the Degognia/Fountain Bluff and Grand Tower Drainage and Levee Districts, protecting a further 56,000 acres. Currently, every segment of these levee systems have "Unacceptable" ratings following Corps inspections and assessment. The Dogtooth Bend Project likewise poses an unusually high potential for flood damage. The Cairo levee system ("Mississippi and Ohio Rivers Levee System at Cairo & Vicinity") is located a few miles downstream of the Dogtooth Bend Project. Although the greatest

effects of wing dikes occur upstream, statistically significant increases in flood levels have also been identified downstream. Corps inspections have identified major deficiencies in the Cairo levee system, leading to its current "Unacceptable" rating in the National Levee Database.

33. My work with local levee commissioners and other informed officials has revealed deep concern and widespread discussion about levee safety and performance during future floods, even without additional stresses. For at least the past decade, local stakeholders have repeatedly called for the St. Louis District of the Corps of Engineers to rigorously and independently assess the cumulative impacts of wing-dike construction in the Middle Mississippi River. Instead, a new wave of dike construction has been undertaken, with each new project evaluated – perfunctorily – on an individual basis and without regard to cumulative effects.

34. The new dike construction projects here – at Dogtooth Bend, Monsenthein/Ivory Landing, Eliza Point/Greenfield Bend, and Grand Tower – pose significant threats of increased flooding and flood risk. They are the latest manifestations of a flawed process that has allowed construction of hundreds of new dikes and dike-like structures that are causing elevated flood stages throughout the Middle Mississippi River. Unless these new dike construction projects are halted to allow their reconsideration based on a comprehensive Supplemental Environmental Impact Statement that takes the foregoing studies and analyses into consideration, needless and potentially severe flooding will likely occur.

35. I declare under penalty of perjury that the foregoing facts are true of my personal knowledge, that the foregoing expressions of professional judgment are honestly held in good faith, that I am competent to and if called would so testify, and that I executed this declaration on June 24, 2014 in Chicago, Illinois.

Nicholas Pinter

Nicholas Pinter, Ph.D

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Yeo, H.K., and J.G. Kang, 2009. Flow analysis around a submerged groyne. Advances in water resources and hydraulic engineering, Vol. 5, Springer, Berlin, 1762–1766.

Yossef, M.F.M., 2004. The effect of submergence level on the resistance of groynes—An experimental investigation. Advances in hydroscience and engineering (CD-ROM), National Center for Computational Hydroscience and Engineering, University, MS.

Yossef, M.F.M., 2005. Morphodynamics of rivers with groynes, Delft University Press, Delft, The Netherlands.

Yossef, M.F.M., and H.J. De Vriend, 201. Flow details near river groynes: Experimental investigation. Journal of Hydraulic Engineering 137: 504–516.

EXHIBIT
1

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EDUCATION

1988 - 1993 PhD., Geology, University of California, Santa Barbara
1986 - 1988 M.S., Geology, Penn State University, Univ. Park, PA
1982 - 1986 B.A., Geology and Archaeology, Cornell University, Ithaca, NY

RESEARCH AREAS

- Geomorphology: the geology of the earth-surface
- Human influences on landscapes and geomorphic processes
- Rivers, flooding, and floodplain management

PROFESSIONAL POSITIONS

1996 - Full Professor (since 7/05), Southern Illinois University
Author: Prentice Hall and John Wiley & Sons
1995 -1996 Postdoctoral Researcher, Yale University

RECENT HONORS/AWARDS

- 2013-2018: Fulbright Specialist, U.S. State Dept., Bureau of Educational and Cultural Affairs (roster)
- 2013: Nominee: W.K. Kellogg Foundation & APLU Engagement Award (to SIU Olive Branch team)
- 2012: Illinois Mitigation Award: Illinois Association of Floodplain and Stormwater Managers
- 2010: Marie Curie Fellowship (IIF), European Commission
- 2010: Fulbright Fellowship (declined; see above)
- 2009: Leo Kaplan Research Award, Sigma Xi, SIU Chapter
- 2008: SIU College of Science, Outstanding Researcher award
- 2007: Alexander von Humboldt Foundation, Germany Research Renewal Fellowship
- 2005, 2006: SIU nominee, Jefferson Fellows Program; National Academy of Sciences
- 2003 Friedrich Wilhelm Bessel Prize; Alexander von Humboldt Foundation
- 2002 John D. and Catherine T. MacArthur Foundation, Research and Writing Award
- 2000 Fulbright Foundation Fellowship
- 1999 Charles A. Lindbergh Foundation Prize

BOOKS, WORKSHOPS, EDITED VOLUMES, and OTHER PROF. ACTIVITIES

Invited Written Testimony: Statement submitted for hearings entitled "A Review of the 2011 Floods and the Condition of the Nation's Flood Control Systems," before the Senate Environment and Public Works Committee, United States Senate, Washington DC, October 18, 2011.

Panelist, U.S. National Academy of Science: Committee on Missouri River Recovery and Associated Sediment Management Issues, 2008-2010.

Associate Editor: Environmental & Engineering Geoscience, Association of Environmental & Engineering Geologists, Denver, CO.

Convener, American Association for the Advancement of Science Workshop: Managing rivers and floodplains for the new millennium. AAAS national meeting, 2006.

External Reviewer, National Research Council, The National Academies: Review of the U.S. Army Corps of Engineers Restructured Upper Mississippi River-Illinois Waterway Navigation Study.

Member, Advisory Board: The Nature Conservancy Great Rivers Center (Upper Mississippi, Parana-Paraguay, and Upper Yangtze River systems).

Lead Editor: Pinter, N., G. Grenerczy, J. Weber, S. Stein, and D. Medak, 2006. The Adria Microplate: GPS Geodesy, Tectonics, and Hazards. Spring Verlag.

Expert Witness: e.g., B&H Towing, Inc., Case No. 06-05-0233 (U.S. District Court, Southern District of W. Virginia); Great Rivers Habitat Alliance v. U.S. Army Corps of Engineers, No. 4:05-CV-01567-ERW (U.S. District Court, Eastern District of Missouri); Great Rivers Habitat Alliance v. City of St. Peters, No. 04-CV-326900 (Circuit Court of Cole County, Missouri); Henderson County Drainage District No. 3 et al. v. United States, No. 03-WL-179780 (Ct. Fed. Cls, Kansas City), etc.

Associate Editor: Geomorphology, Elsevier Science, 2004-2008

Instructor, European Union Advanced School on Tectonics: 3D Monitoring of Active Tectonic Structures, International Centre for Theoretical Physics, Trieste, April 18-22, 2005.

Convener, NATO Advanced Research Workshop: The Adria microplate: GPS geodesy, tectonics, and hazards. Veszprém, Hungary; April, 2004.

Convener, Pardee Keynote Symposium: Pinter, N., and J.F. Mount, 2002, Flood hazard on dynamic rivers: Human modification, climate change, and the challenge of non-stationary hydrology. Geological Society of America national meeting, 2002.

Author: Keller, E.A. and N. Pinter, 2002. Active Tectonics: Earthquakes and Landscape. Prentice-Hall.

Co-Editor: Burbank, D.W., and N. Pinter, 1999. Landscape evolution: The interactions of tectonics and surface processes. Basin Research, vol. 11, num. 1.

Author: Pinter, N, 1996. Exercises in Active Tectonics. Prentice Hall.

Convener and Instructor: Pazzaglia, F.J., and N. Pinter, 1996. Geomorphic expression of active tectonics. Short course at the 1996 Geological Society of America meeting, Denver.

Convener, Theme Session: N. Pinter, and D.W. Burbank, 1996. Feedbacks between tectonics and surface processes in orogenesis. Geological Society of America meeting, Denver.

Author: Pinter, N., and S. Pinter, 1995. Study Guide for Environmental Science. J. Wiley & Sons.

REFERENCES

Thomas Gardner	Trinity University, San Antonio, TX 78212	tgardner@trinity.edu	210-736-7655
Edward Keller	Univ. of California, Santa Barbara, CA 93106	keller@geol.ucsb.edu	805-893-4207
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Seth Stein	Northwestern Univ., Evanston, IL 60208	seth@earth.northwestern.edu	847-491-5265

FUNDED PROJECTS

Active: NSF Infrastructure Management for Extreme Events: Community resilience through pro-active mitigation in the rural Midwest.

Active: NSF IGERT: Multidisciplinary, team-based training watershed science and policy. (Lead PI: Pinter; $3.2 million) **+ International Supplement**

Active: FEMA: Illinois multi-hazard mitigation initiative (Lead PI: Pinter; with Indiana University-Purdue University at Indianapolis). ~40 awarded + ~12 pending.

NSF RAPID: A massive floodplain reconnects: physical and biotic responses of the Birds Point levee breach in the Mississippi River (J. Garvey, lead PI).

IEMA: Illinois statewide flood-hazard assessment (J. Remo, lead PI).

Walton Family Foundation: Olive Branch, IL Relocation Initiative: Community Disaster-Recovery Networking

NSF Sedimentology and Paleobiology program: Testing hypotheses of latest Pleistocene paleo-environmental collapse, Northern Channel Islands, California (Lead PI: Pinter; collaborative project with Northern Arizona University; Univ. of Oregon)

Emergency Management Institute curricula: HAZUS-MH for earthquakes.

U.S. Steel: Levee-breach modeling, Metro East Drainage and Levee District area.

European Commission, Marie Curie IIF Program: Early anthropogenic signatures on landscapes: geomorphic, paleobotanical, and other paleo-environmental fingerprints.

NSF, Geography and Regional Science: A multivariate geospatial model of levee impacts on flood heights, Lower Mississippi River + **International Supplement** awarded

National Geographic Society: Testing a hypothesis of latest Pleistocene paleo-environmental collapse, Northern Channel Islands, California.

USGS Upper Midwest Environmental Sciences Center: Development of a virtual hydrologic and geospatial data repository for the Mississippi River System

NSF, Office of International Science and Engineering: U.S.-Chile: Morphotectonic evolution of the U.S.-Chile: Mejillones Peninsula, northern Chile using precise GPS measurement of uplifted coastal terraces

NSF Hydrologic Sciences Program: Multivariate geospatial analysis of engineering and flood response, Mississippi River System, USA.

NSF, International Science and Engineering: US-Chile cooperative research on the Cenozoic paleoceanographic and paleoclimatic evolution of northern and central Chile. (Ishman and Pinter)

NATO Science Program: The Adria microplate: GPS geodesy, tectonics, and hazards.

John D. and Catherine T. MacArthur Foundation: Exporting Natural Disasters: Flooding and Flood Control on Transboundary Rivers

NATO: The Adria Microplate: Postdoctoral Fellowship for Dr. G. Grenerczy.

USGS National Cooperative Geologic Mapping Program (6/03-5/04). Plio-Pleistocene Deposits of the White/Inyo Mountains Range Front, Inyo and Mono Counties, CA

Alexander von Humboldt Foundation: Human forcing of hydrologic change and magnification of flood hazard on German Rivers

NASA (9/01-8/02)). Assessing mass wasting and landslide susceptibility using GIS and remotely sensed imagery, Santa Cruz Island, California. (ESS Fellowship for E. Molander)

Association of State Floodplain Managers (9/01-8/02). Rapid revision of flood-hazard mapping. (Fellowship for R. Heine)

Missouri Coalition for the Environment (7/01-5/02). Hydrologic history of the Lower Missouri River.

NOAA Channel Islands National Marine Sanctuary (12/99-6/02). Orthorectification of 1997, pre-El Niño air-photo set from the California Channel Islands.

Petroleum Research Fund (7/99-10/01). Timing and rates of basin inversion from tectonic geomorph-ology, Pannonian Basin, Hungary. (**Supplement** [5/00-4/01] for an ACS-PRF Summer Fellow)

USGS National Cooperative Geologic Mapping Program (5/00-4/01). Mapping landslide susceptibility, Santa Cruz Island, California: A field- and GIS-based analysis.

National Park Service, Channel Islands National Park (4/00-9/00). Orthorectification of 1998, post-El Niño air-photo set from the California Channel Islands.

USGS National Cooperative Geologic Mapping Program (6/99-5/00). Mapping coastal terraces and Quaternary cover on Santa Rosa and San Miguel Islands, California, using dual-frequency kinematic GPS positioning.

NSF Active Tectonics Program (3/97-2/00), (**Supplement** granted). Testing models of fault-related folding, Northern Channel Islands, California.

NASA (9/00-8/01)). Assessing mass wasting and landslide susceptibility using GIS and remotely sensed imagery, Santa Cruz Islands, California. (ESS Fellowship for W.D. Vestal)

National Earthquake Hazards Reduction Program (7/97-12/99): Slip on the Channel Islands/Santa Monica Mountains Thrust. (**Supplement** granted)

NSF, Instrumentation and Facilities Program (8/97-7/99): Acquisition of a GIS-dedicated UNIX workstation laboratory.

SIU Office of Research Development (8/97-5/99). Effects of levee construction and channelization on stage-discharge flood response of the Upper Mississippi River.

National Research Council (1997). Active tectonics of the Pannonian Basin, Hungary.

National Earthquake Hazards Reduction Program (2/92-7/93). Latest Pleistocene to Holocene rupture history of the Santa Cruz Island fault. (with Ed Keller)

PUBLICATIONS

Books: National Research Council, 2010. Missouri River Planning: Recognizing and Incorporating Sediment Management. National Academy Press: Washington, DC.

Pinter, N., G. Grenerczy, J. Weber, S. Stein, and D. Medak (eds.), 2006. The Adria Microplate: GPS Geodesy, Tectonics, and Hazards. Springer Verlag.

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Papers: Huthoff, F., N. Pinter, and J.W.F. Remo, 2014. Reply to discussion of "Theoretical analysis of stage magnification caused by wing dikes, Middle Mississippi River, USA". Journal of Hydraulic Engineering, in press.

Huthoff, F., J.W.F. Remo, and N. Pinter, in press. Improving flood preparedness using hydrodynamic levee-breach and inundation modeling: Middle Mississippi River, USA. Journal of Flood Risk Management.

Pinter, N., S. Baer, L. Chevalier, R. Kowalchuk, C. Lant, and M. Whiles, 2013. An "IGERT" model for interdisciplinary doctoral education in water-related science and policy. Journal of Contemporary Water Research and Education, 150: 53-62.

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Huthoff, F., H. Barneveld, N. Pinter, J. Remo, H. Eerden, 2013. Optimizing design of river training works using 3-dimensional flow simulations. In Smart Rivers 2013 (Conference Proceedings), Liege, Belgium and Maastricht , Netherlands, 23-27 September, 2013.

Remo, J.W.F., and N. Pinter, 2012. Hazus-MH earthquake modeling in the central USA. Natural Hazards, 63:1055–1081.

Dierauer, J., N. Pinter, J.W.F. Remo, 2012. Evaluation of Levee Setbacks for Flood-Loss Reduction, Middle Mississippi River, USA. Journal of Hydrology, 450: 1-8.

Pinter, N., J. Dierauer, J.W.F. Remo, 2012. Flood-damage modeling for assessing impacts of flood frequency adjustment, Middle Mississippi River, USA. Hydrologic Processes, 26: 2997–3002.

Remo, J.W.F., M. Carlson, N. Pinter, 2012. Hydraulic and flood-loss modeling of levee, floodplain, and river management strategies, Middle Mississippi River, USA. Natural Hazards, 61: 551-575.

Pinter, N., 2012. Early history of the Upper Mississippi River In Brad Walker (Ed.), Our Future? A Vision for a Land, Water and Economic Ethic in the Upper Mississippi River Basin, pp. 10-12. St. Louis: Missouri Coalition for the Environment.

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Heine, R.A., and N. Pinter, 2012. Levee effects upon flood levels: An empirical assessment. Hydrological Processes, 26: 3225–3240.

Boslough, M., K. Nicoll, V. Holliday, T. L. Daulton, D. Meltzer, N. Pinter, A. C. Scott, T. Surovell, Ph. Claeys, J. Gill, F. Paquay, J. Marlon, P. Bartlein, C. Whitlock, D. Grayson, and T. Jull, 2011. Arguments and evidence against a Younger Dryas impact event. Proceedings of the AGU Chapman Conference on Climates, Past Landscapes, and Civilizations, Santa Fe, NM, 21-25 March, 2011.

Bormann, H., N. Pinter, and S. Elfert, 2011. Hydrological signatures of flood trends on German rivers: flood frequencies, flood heights and specific stages. Journal of Hydrology, 404: 50-66.

Pinter, N., A.C. Scott, T.L. Daulton, A. Podoll, C. Koeberl, R.S. Anderson, and S.E. Ishman, 2011. The Younger Dryas impact hypothesis: A requiem. Earth-Science Reviews, 106: 247–264.

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Flor, A.D., N. Pinter, and J.W.F. Remo, 2010. Evaluating levee failure susceptibility on the Mississippi River using logistic regression analysis. Engineering Geology, 116: 139-148.

Daulton, T.L., N. Pinter, and A.C. Scott, 2010. No evidence of nanodiamonds in Younger Dryas sediments to support an impact event. PNAS, 107: 16043–16047.

Scott, A.C., N. Pinter, M.E. Collinson, M. Hardiman, R.S. Anderson, A.P.R. Brain, S.Y. Smith, F. Marone, and M. Stampanoni, 2010. Fungus, not comet or catastrophe, accounts for carbonaceous spherules in the Younger Dryas 'impact layer'. Geophysical Research Letters, 37: doi:10.1029/2010GL043345.

Pinter, N., A.A. Jemberie, J.W.F. Remo, R.A. Heine, and B.A. Ickes, 2010. Empirical modeling of hydrologic response to river engineering, Mississippi and Lower Missouri Rivers. River Research and Applications, 26: 546-571.

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Anderson, R.S., S. Starratt, R.B. Jass, and N. Pinter, 2009. Fire and vegetation history on Santa Rosa Island, Channel Islands: Long-term environmental change in southern California. Journal of Quaternary Science, DOI: 10.1002/jqs.

Pinter, N., 2009. Non-stationary flood occurrence on the Upper Mississippi-Lower Missouri River system: Review and current status. In R. E. Criss and Timothy M. Kusky (Eds.), Finding the Balance between Floods, Flood Protection, and River Navigation, pp. 34-40. Saint Louis University, Center for Environmental Sciences. Available online, URL: http://www.ces.slu.edu/.

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

Pinter, N., and S.E. Ishman, 2008. Reply to comments on "Impacts, mega-tsunami, and other extraordinary claims." GSA Today, vol. 18(6): e14.

Szilagyi, J., N. Pinter, and R. Venczel, 2008. Application of a routing model for detecting channel flow changes with minimal data. Journal of Hydrologic Engineering, 13: 521-526.

Remo, J.W.F., N. Pinter, B. Ickes, and R. Heine, 2008. New databases reveal 200 years of change on the Mississippi River System. Eos, 89(14): 134-135.

Pinter, N., and S.E. Ishman, 2008. Impacts, mega-tsunami, and other extraordinary claims. GSA Today, 18(1): 37-38.

Remo, J.W.F, and Pinter, N., 2007. The use of spatial systems, historic remote sensing and retro-modeling to assess man-made changes to the Mississippi River System. In: Zaho, P. et al. (eds.), Proceedings of International Association of Mathematical Geology 2007: Geomathematics and GIS Analysis of Resources, Environment and Hazards. State Key Laboratory of Geological Processes and Mineral Resources, Beijing, China, pp. 286-288.

Bada, G., Grenerczy, G., Tóth, L., Horváth, F., Stein, S., Cloetingh, S., Windhoffer, G., Fodor, L., Pinter, N., Fejes, I., 2007. Motion of Adria and ongoing inversion of the Pannonian basin: Seismicity, GPS velocities and stress transfer. In: Stein, S., Mazzotti, S., (Eds.), Continental Intraplate Earthquakes: Science, Hazard, and Policy Issues. Geological Society of America Special Paper 425, p. 243–262, doi: 10.1130/2007.2425(16).

Remo, J.W.F., and N. Pinter, 2007. Retro-modeling of the Middle Mississippi River. Journal of Hydrology 337: 421-435.

Pinter, N., B.S. Ickes, J.H. Wlosinski, and R.R. van der Ploeg, 2006. Trends in flood stages: Contrasting trends in flooding on the Mississippi and Rhine river systems. Journal of Hydrology, 331: 554-566.

Pinter, N., 2006. New Orleans revival recipes. Issues in Science and Technology, 22(3): 5-6.

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Pinter, N., R.R. van der Ploeg, P. Schweigert, and G. Hoefer, 2006. Flood Magnification on the River Rhine. Hydrological Processes, 20: 147-164.

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Pinter, N., 2005. Policy Forum: One step forward, two steps back on U.S. floodplains. Science, 308: 207-208.

Pinter, N., 2005. Applications of tectonic geomorphology for deciphering active deformation in the Pannonian Basin, Hungary. In L. Fodor and K. Brezsnyánszky (eds.), Proceedings of the Workshop on "Applications of GPS in Plate Tectonics in Research on Fossil Energy Resources and in Earth-quake Hazard Assessment, Occasional Papers of the Geological Institute of Hungary, 204: 25-51.

Pinter, N., and W.D. Vestal, 2005. El Niño-driven landsliding and postgrazing recovery, Santa Cruz Islands, California. Journal of Geophysical Research, 110, F2, doi. 10.1029/2004JF000203.

Pinter, N., and R.A. Heine, 2005. Hydrodynamic and morphodynamic response to river engineering documented by fixed-discharge analysis, Lower Missouri River, USA. Journal of Hydrology, 302: 70-91.

Schweigert, P., N. Pinter, and R.R. van der Ploeg, 2004. Regression analysis of weather effects on the annual concentrations of nitrate in soil and groundwater. Journal of Plant Nutrition and Soil Science, 167: 309-318.

Pinter, N., K. Miller, J.H. Wlosinski, and R.R. van der Ploeg, 2004. Recurrent shoaling and dredging on the Middle and Upper Mississippi River, USA. Journal of Hydrology, 290: 275-296.

Scott, A.T., and N. Pinter, 2003. Extraction of coastal terraces and shoreline-angle elevations from digital terrain models, Santa Cruz and Anacapa Islands, California. Physical Geography, 24: 271-294.

Gieska, M., R.R. van der Ploeg, P. Schweigert, and N. Pinter, 2003. Physikalische Bodendegradierung in der Hildesheimer Börde und das Bundes-Bodenschutzgesetz. Berichte über Landwirtschaft 81(4): 485-511.

Pinter, N., C.C. Sorlien, and A.T. Scott, 2003. Isostatic subsidence in response to thrust faulting and fold growth. American Journal of Science, 303: 300-318.

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Pinter, N., R. Thomas, and J.H. Wlosinski, 2002. *Reply* to U.S. Army Corps of Engineers *Comment* on "Assessing flood hazard on dynamic rivers." Eos: Transactions of the American Geophysical Union, 83(36): 397-398.

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Pinter, N., B. Johns, B. Little, and W.D. Vestal, 2001. Fault-related folding in California's Northern Channel Islands documented by rapid-static GPS positioning. GSA Today, 11(5): 4-9.

Pinter, N., R. Thomas, and N.S. Philippi, 2001. Side-stepping environmental conflicts: The role of natural-hazards assessment, planning, and mitigation. E. Petzold-Bradley, A. Carius, and A. Vincze (eds.), Responding to Environmental Conflicts: Implications for Theory and Practice, p. 113-132. Dordrecht: Kluwer Academic Publishers.

Lueddecke, S.B., N. Pinter, and S. McManus, 2001. Greenhouse effect in the classroom: A project- and laboratory-based curriculum. Journal of Geological Education, 49: 274-279.

Pinter, N., R. Thomas, and J.H. Wlosinski, 2000. Regional impacts of levee construction and channelization, Middle Mississippi River, USA. In J. Marsalek, W.E. Watt, E. Zeman, and F. Sieker (eds.), Flood Issues in Contemporary Water Management, p. 351-361. Dordrecht: Kluwer Academic Publishers.

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Pinter, N., C.C. Sorlien, and A.T. Scott, 1998. Late Quaternary folding and faulting of the Santa Cruz Island, California. In P.W. Weigand (ed.), Contributions to the Geology of the Northern Channel Islands, Southern California. Pacific Section, American Association of Petroleum Geologists: Bakersfield, CA, MP-45: 111-122.

Pinter, N., S.B. Lueddecke, E.A. Keller, and K. Simmons, 1998. Late Quaternary slip on the Santa Cruz Island fault, California. Geological Society of America Bulletin, 110: 711-722.

Lueddecke, S.B., N. Pinter, and P. Gans, 1998. Plio-Pleistocene ash falls, sedimentation, and range-front faulting along the White-Inyo Mountains front, California. Journal of Geology, 106: 511-522.

Pinter, N., and M.T. Brandon, 1997. How erosion builds mountains. Scientific American, 276(4): 74-79.

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Sorlien, C.C., and N. Pinter, 1997. Faulting and folding on Santa Cruz Island, California. In J.R. Boles and W. Landry (eds.), Santa Cruz Island Geology Field Trip Guide, San Diego: San Diego Association of Geologists, pp. 72-90.

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Pinter, N., and E.A. Keller, 1995. Geomorphic analysis of neotectonic deformation, northern Owens Valley, California. Geologische Rundschau, 84: 200-212.

Pinter, N., E.A. Keller, and R.B. West, 1994. Relative dating of terraces of the Owens River, northern Owens Valley, California and correlation with moraines of the Sierra Nevada. Quaternary Research, 42: 266-276.

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Gardner, T.W., D. Verdonck, N. Pinter, R.L Slingerland, K.P. Furlong, T.F. Bullard, and S.G. Wells, 1992. Quaternary uplift astride the aseismic Cocos Ridge, Pacific coast, Costa Rica. Geological Society of America Bulletin, 104: 219-232.

Pinter, N., and M.M. Fulford, 1991. Late Cretaceous basement foundering of the Rosario embayment, Peninsular Ranges forearc basin: Backstripping of the El Gallo Formation, Baja California Norte, Mexico. Basin Research, 3: 215-222.

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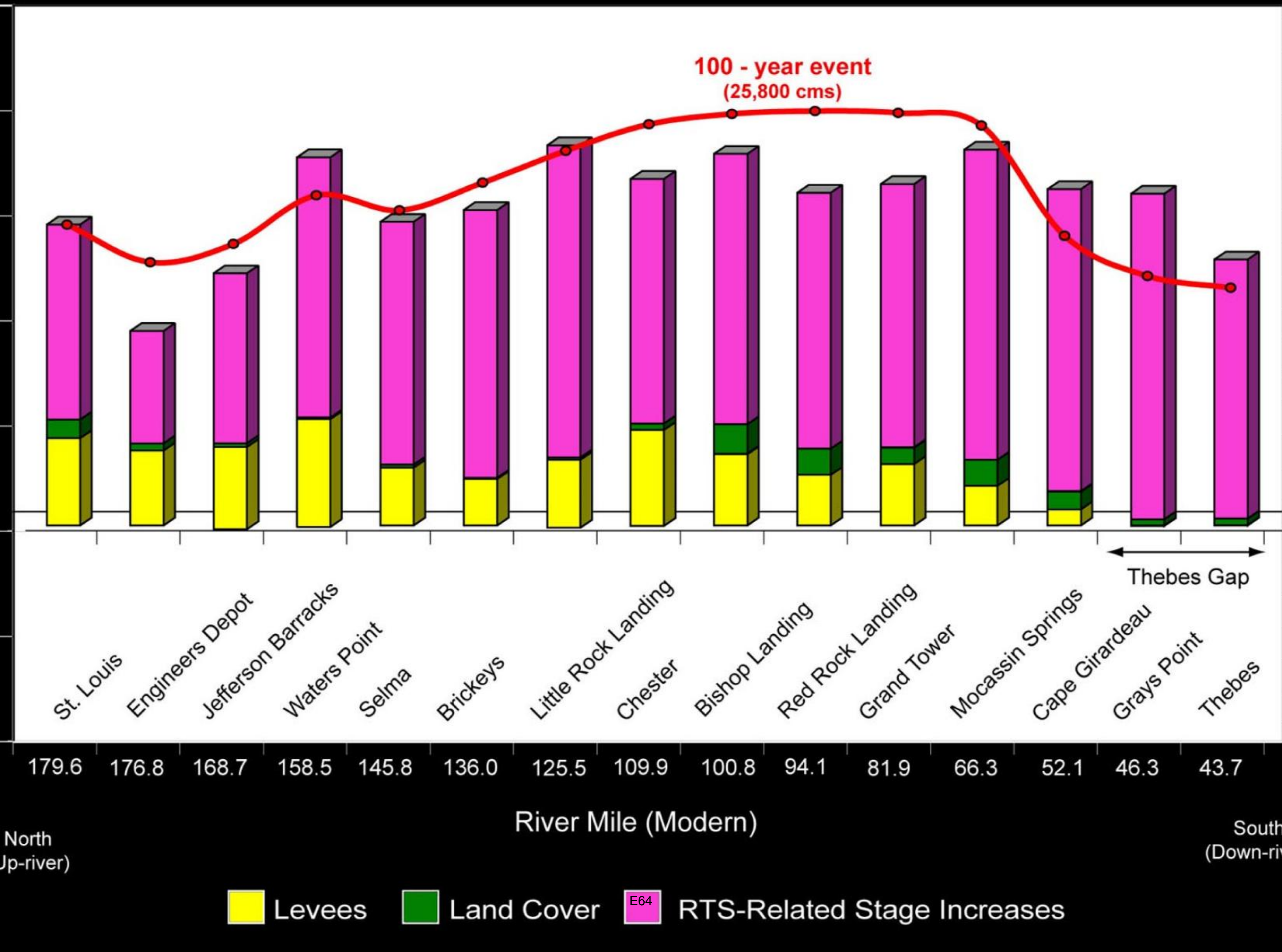
EXHIBIT
2



100 - year event
(25,800 cms)
Thebes Gap
St. Louis
Engineers Depot
Jefferson Barracks
Waters Point
Selma
Brickeys
Little Rock Landing
Chester
Bishop Landing
Red Rock Landing
Grand Tower
Mocassin Springs
Cape Girardeau
Grays Point
Thebes
179.6
176.8
168.7
158.5
145.8
136.0
125.5
109.9
100.8
94.1
81.9
66.3
52.1
46.3
43.7
River Mile (Modern)
North
(Up-river)
South
(Down-river)
Levees
Land Cover
E64
RTS-Related Stage Increases

EXHIBIT
3

doi:10.2489/jswc.68.4.89A

FEATURE

Impacts of 2011 Len Small levee breach on private and public Illinois lands

Kenneth R. Olson and Lois Wright Morton

Agriculture, the dominant land use of the Mississippi River Basin for more than 200 years, has substantively altered the hydrologic cycle and energy budget of the region (NPS 2012). Extensive systems of US Army Corps of Engineers (USACE) and private levees from the Upper Mississippi River near Cape Girardeau, Missouri, southward confine the river and protect low-lying agricultural lands, rural towns, and public conservation areas from flooding. The Flood of 2011 severely tested these systems of levees, challenging public officials and landowners to make difficult decisions, and led to extensive damage to crops, soils, buildings, and homes. One of these critical levees (figure 1), the Len Small, failed, creating a 1,500 m (5,000 ft) breach (figure 2) where fast-moving water scoured farmland, deposited sediment, and created gullies and a crater lake. The Len Small levee, built by the Levee and Drainage District on the southern Illinois border near Cairo to protect private and public lands from 20-year floods, is located between mile marker 21 and mile marker 35 (figure 1). It connects to Fayville levee that extends to Mississippi River mile marker 39, giving them a combined length of 34 km (22 mi) protecting 24,000 ha (60,000 ac) of farmland and public land, including the Horseshoe Lake Conservation area. The repair of the breached levee, crater lake, gullies, and sand deltas began in October of 2011 and continued for one year.

HISTORICAL GEOLOGICAL FEATURES OF THE WESTERN ALEXANDER COUNTY

The Mississippi River is a meandering river of oxbows and cutoffs, continuously eroding banks, redepositing soil, and changing paths. Its willful historic meandering is particularly apparent in western Alexander County, Illinois, where a topographical map shows swirls and curves and an oxbow lake, Horseshoe Lake, where the river once flowed south of Thebes and east of the modern day Len Small levee. The loess-covered upland hills (Fehrenbacher et al. 1986) of the Shawnee National Forest just north of Route 3 (figure 1) give way to a low-lying plain between the Mississippi and Ohio rivers. The ancient Ohio River drained through the Cache River valley during the Altonian and Woodfordian glacial advances (60,000 to 30,000 years B.P.) and converged with the Mississippi River waters just northwest of Horseshoe Lake. The Cache River valley is 3 km (1.9 mi) wide and carried a substantive flow of water from the eastern Ohio River Basin

Figure 1

Map of Alexander County, Illinois, including the Len Small levee and the northern part of the Commerce to Birds Point levee, Missouri, areas.

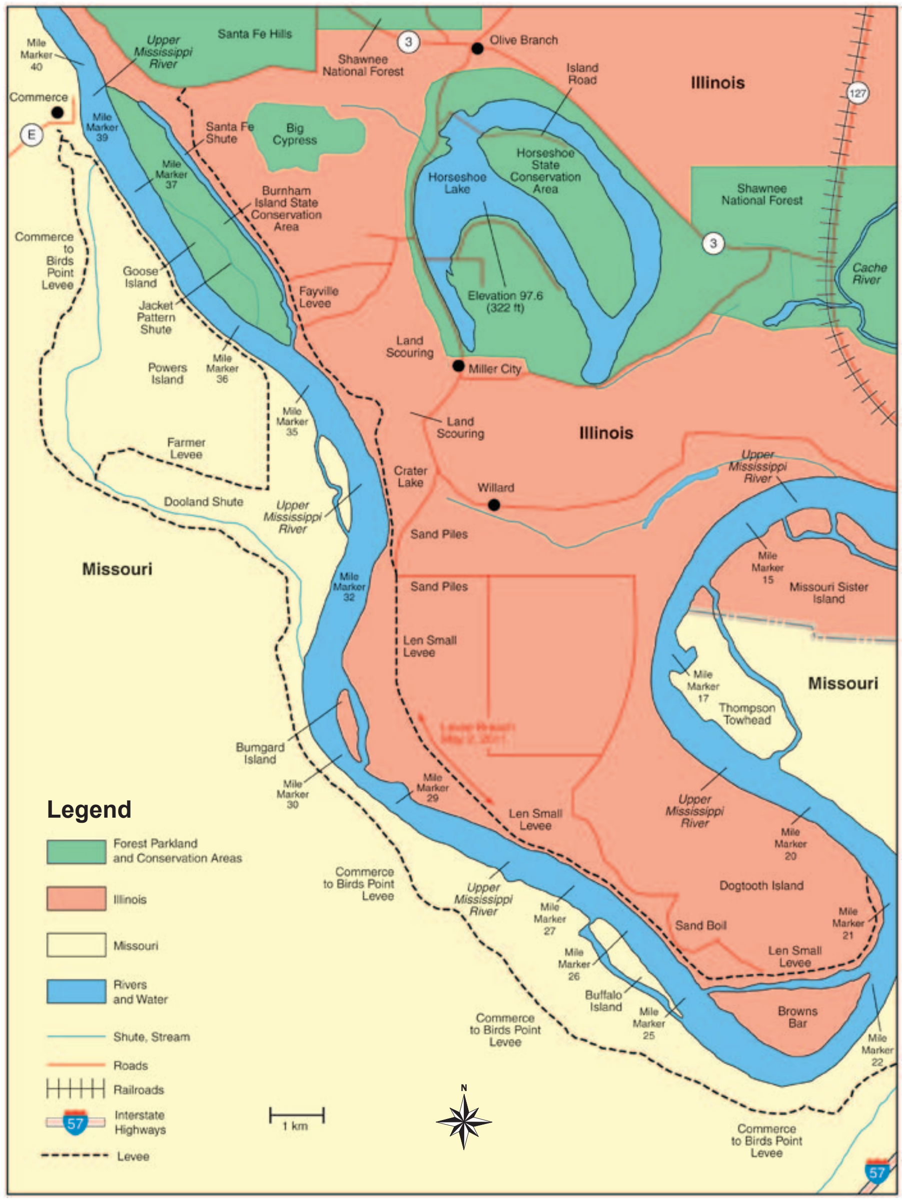


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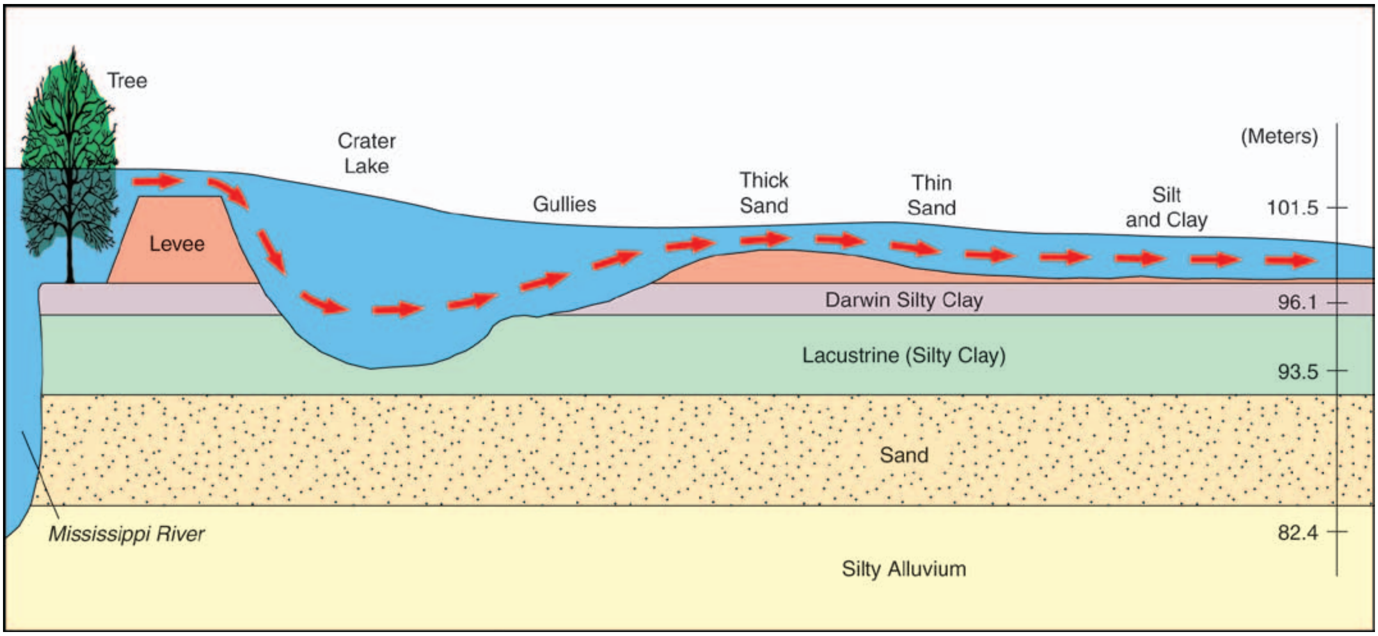
Figure 2

Diagram of Len Small levee failure and creation of crater lake, gullies, and sand delta.



in addition to the local waters from the Cache River valley into the Mississippi River valley. Historically, the region has been a delta, confluence and bottomlands dating back 30,000 to 800,000 years B.P., with many of the Illinois lands shown on the maps located on both sides of the Upper Mississippi River as its channel changed locations over time. As a result, the fertile farmland of western Alexander County soils formed in alluvial and lacustrine deposits.

Horseshoe Lake (figure 3), a former oxbow and remnant of a large meander of the Mississippi River, is now a state park of 4,080 ha (10,200 ac) (Illinois DNR 2012). This oxbow lake, formerly a wide curve in the river, resulted from continuous erosion of its concave banks and soil deposition on the convex banks. As the land between the two concave banks narrowed, it became an isolated body of water cutoff from the main river stem through lateral erosion, hydraulic action, and abrasion. With 31 km (20 mi) of shoreline, the 1.3 m (4 ft) deep lake is the northernmost natural range for Bald cypress (*Taxodium distichum* L.) and Tupelo (*Nyssa* L.) trees (figure 3) and has an extensive growth of American lotus (*Nelumbo lutea*), a perennial aquatic plant, and native southern hardwoods which grow well in lowlands and areas which are subject to seasonal flooding.

Figure 3

The bald cypress trees and American lotus at Horseshoe Lake conservation area.

The agricultural lands which surround this oxbow lake are highly productive alluvial soils —mostly Weinbach silt loam, Karnak silty clay, Sciotoville silt loam, and Alvin fine sandy loam. Almost two-thirds of the area (16,000 ha [40,000 ac]) protected by the Len Small and Fayville levees is privately owned. Corn (*Zea mays* L.), soybeans (*Glycine max* L.), and wheat (*Triticum* L.) are the primary crops, with some rice (*Oryza sativa* L.) grown in this area.

THE COMMERCE TO BIRDS POINT, CAIRO, AND WESTERN ALEXANDER COUNTY LEVEES

In early May of 2011, the floodwaters at the Ohio River flood gage in Cairo, Illinois, had reached 18.7 m (61.7 ft) (NOAA 2012). The Ohio River was 6.7 m (22 ft) above flood stage and had been causing a back-up in the Mississippi River floodwater north of the Cairo confluence prior to the USACE opening of the Birds Point–New Madrid Floodway. For more than a month, the Mississippi River back-up placed significant pressure on the Len Small and Fayville levees (figure 1). As a result, approximately 1,500 m (5,000 ft) of the Len Small levee was breached (figure 2) near mile marker 29 (figure 1) on the morning of May 2, 2011.

The flood protection offered by the Len Small and Fayville levees is important to the landowners, homeowners, and farmers in southwestern Alexander County, Illinois. However, the Len Small and Fayville levees are not the mainline levees which control the width and height of the Mississippi River. The controlling mainline levees are the frontline Cairo levee located in Illinois (Olson and Morton 2012a) and the Commerce to Birds Point levee in Missouri (figure 4). These two frontline levees, by design, are much higher and stronger than the Len Small and Fayville levees. The Len Small and Fayville levees were built by the local levee district and are not part of the Mississippi River and Tributaries project for which USACE has responsibility (figure 5). The Cairo levee has a height of 19.4 m (64 ft), or 101.4 m (334.5 ft) above sea level, and levee failure would destroy the City of Cairo. The frontline Commerce to Birds Point levee has a height of 19.8 m (65.5 ft), and its failure would result in more than 1 million ha (2.5 million ac) of agricultural bottomlands in Missouri Bootheel and Arkansas on west side of the Mississippi River being flooded (figure 5). Commerce to Birds Point levee connects to a setback levee on the west side of the Birds Point–New Madrid Floodway, which extends the protection another 51 km (33 mi) to the south where it joins the frontline levee at New Madrid, Missouri, further extending the protection of the Bootheel bottomlands (Camillo 2012; Olson and Morton, 2012a, 2012b, 2013). The failure of the Hickman (Kentucky) levee on the east side of the Mississippi River would have resulted in the flooding of 70,000 ha (170,000 ac) of protected bottomlands in Tennessee and Kentucky (figure 5). The floodwater height and pressure on the Commerce to Birds Point and Birds Point to New Madrid levees has increased over the years during Mississippi River flooding events with the construction of the Len Small and Fayville levees and with a strengthening of the levee near Hickman, Kentucky, which had the effect of narrowing the Mississippi River Floodway corridor and removing valuable floodplain storage areas for floodwaters.

Figure 4

The Commerce to Birds Point mainline US Army Corps of Engineers levee.

THE MISSISSIPPI RIVER COMMISSION AND ITS ROLE IN LEVEE CONSTRUCTION ALONG THE MISSISSIPPI RIVER AND TRIBUTARIES

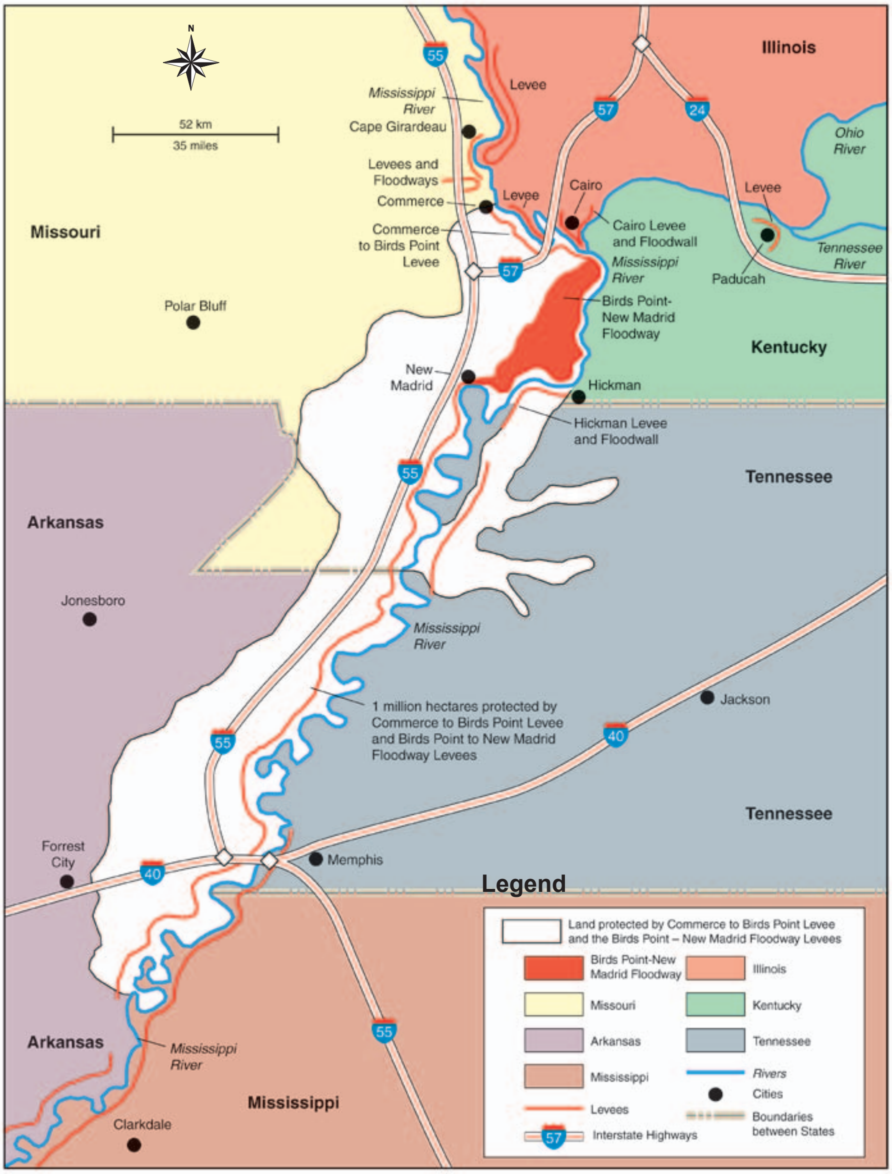
The Mississippi River Commission (MRC) was established by Congress in 1879 to combine the expertise of the USACE and civilian engineers to make the Mississippi River and tributaries a reliable shipping channel and to protect adjacent towns, cities, and agricultural lands from destructive floods (Camillo 2012). The Mississippi River Commission has a seven-member governing body. Three of the officers are from the USACE, including the chairman who is the final decision maker when it comes to decisions like opening the floodways. Another member is an Admiral from National Oceanic and Atmospheric Administration (NOAA), and the other three members are civilians, with at least two of the civilian members being civil engineers. Each member is appointed by the President of the United States. Senate confirmation is no longer necessary. The MRC is the lead federal agency responsible for addressing the improvement and maintenance of the Mississippi River and Tributaries project, including flow and transportation systems.

Between 1899 and 1907, MRC assisted local levee districts in Missouri with construction of a federal levee between Birds Point, Missouri, and Dorena, Illinois. At that time, the MCR jurisdiction was limited to the areas below the confluence of the Ohio and Mississippi rivers (Camillo 2012; Olson and Morton 2012a, 2012b), which is at the southern tip of Illinois (Fort Defiance State Park). This levee is located approximately where the current frontline levee of the Birds Point–New Madrid Floodway was constructed between 1928 and 1932 after Birds Point to Dorena levee failed in 1927.

In 1902, the MRC helped Kentucky construct a levee from the Hickman,

Figure 5

The bottomlands in Missouri and Arkansas protected by the Commerce to Birds Point mainline levee and bottomlands in Tennessee and Kentucky protected by the Hickman levee.



Kentucky, bluff to Tennessee, where it connected with another levee to extend the levee system 7.8 km (5 mi) to Slough Landings, Tennessee. During this time period, a portion of the natural floodplain near Cape Girardeau was walled off by a local Missouri levee to provide protection of farmland adjacent to the river (figure 1). These two levees narrowed the river channel and during high-water events on the Mississippi River increased floodwater back-up, placing tremendous pressure on the existing systems of levees and floodwalls above and below the Cairo confluence (Camillo 2012; Olson and Morton 2012a, 2012b).

The Commerce to Birds Point levee (figure 5) has long been considered by the MRC and the USACE to be the most critical levee in the Mississippi River valley since it protects nearly 1 million ha (2.5 million ac) of prime agricultural bottomlands in Arkansas and Missouri Bootheel. The Commerce to Birds Point levee, shown in figures 1 and 4, had two major threats (1973 and 1993) from past major flooding events. During the 1973 flood, a 455 m (1,500 ft) section of the Commerce to Birds Point levee fell into the Mississippi River. The caving extended to the top of the levee. The USACE Memphis District placed 21,600 t (18,000 tn) of riprap stone carried in by barges to prevent additional caving (Camillo 2012). The Len Small levee on the Illinois side of the Mississippi River (figure 1) and across from the Commerce to Bird Point levee, Missouri, had historically overtopped or failed during larger flooding events, thereby reducing the pressure on the Commerce to Birds Point levee. The local levee and drainage district and owners of the Len Small levee strengthened their levee during the 1980s, which increased pressure on the Commerce to Birds Point levee when the river flooded. As a result, in the 1993 flood event, the Len Small levee held and the Mississippi remained confined as it climbed to within 1 m (3 ft) of the top of the Commerce to Birds Point levee. Sand boils developed in the Commerce levee were treated until the underseepage stabilized. In 1995, USACE Memphis District raised the height and strengthened the Commerce to Birds Point levee and installed relief wells.

LOCAL AND MISSISSIPPI RIVER FLOODING OF FARMLAND AND TOWNS LOCATED IN WESTERN ALEXANDER COUNTY

The 2011 flood and record peak on the Ohio River caused the Mississippi River near the confluence to back up for many kilometers to the north and affected all bottomlands in Alexander County, Illinois, that were located on the east side of Upper Mississippi River (figure 1). Since the gradient on the Mississippi River is between 12 and 25 cm km^{-1} (0.5 to 1 ft mi^{-1}), the Mississippi River water rose an additional 5.5 m (18 ft) above the flood stage further north. This occurred at a time when the Ohio River was 6.7 m (22 ft) above flood stage and the Mississippi River north of Cape Girardeau, Missouri, was 3 m (9.9 ft) above flood stage. Cities farther to the north like St. Louis, Missouri, were only subjected to floodwaters 2 m (6.6 ft) above flood stage as a result of water flowing from the Upper Mississippi and Missouri rivers.

The May 2nd topping and breach of the Len Small levee occurred just a few hours before the pressure of record flood levels was relieved with the opening of the Birds Point–New Madrid Floodway at 10:00 p.m. Illinois farmers, landowners, and homeowners protected by the Len Small levee might have benefited if the floodway had been opened on April 28th or 29th (2011) when the first weather forecast was issued with a projected Ohio River peak level of 18.3 m (60.5 ft) or higher on the Cairo gage. This is the criteria set in 1986 USACE operational plan that needs to be met before the USACE can artificially breach the levee at Birds Point and use New Madrid Floodway to relieve river pressure and store excess floodwaters. There were a number of reasons why the USACE did not open the floodway on April 28, 2011, and waited until the evening of May 2, 2011. These reasons included the possibility that the forecasted peak would never happen and concern about the damage it would have caused to the 53,200 ha (133,000 ac) of farmland and buildings in the Birds Point–New Madrid Floodway. Consequently, the USACE continued to monitor the situation and waited a few more days before making the final decision to load the trinitrotoluene (TNT) (once loaded it would be difficult to remove if not exploded) into the Birds Point fuse plugs and blow it up on May 2, 2011 (Camillo 2012). The other reasons for the delay were the mega sand boil in Cairo, the heavy local rains in the area of the confluence of the Ohio and Mississippi rivers, and the new peak forecast of 19.2 m (63.5 ft) (Camillo 2012). All these events occurred on May 1, 2011, the day the Supreme Court rejected the Missouri Attorney General's lawsuit filed in an attempt to block the USACE from opening the Birds Point–New Madrid Floodway in an effort to protect Missouri citizens and property.

Flooding of Alexander County from the Ohio and Cache rivers resulted in some flooding in the town of Olive Branch in late April and on May 1, 2011. This was before the Len Small breach occurred on May 2, 2011, and there was some damage to private and public lands prior to the breach. Floodwater from the Mississippi River added to the local flooding caused by the middle Cache River in late April when the record high Ohio River returned to its historic path and poured through the 2002 unrepaired Karnak levee breach into the middle Cache River valley and flooded the Olive Branch and Horseshoe Lake area. These floodwaters eventually drained back into the Mississippi River near Route 3 and through the diversion near mile marker 15 (figure 1) and through the Len Small levee breach.

Figure 6

Land scouring, gullies, and erosion north of the Len Small levee breach.

As a result of Cache River valley floodwater flowing through the Karnak levee breach and the additional Mississippi River floodwaters pushing through the Len Small breach, 4,000 ha (10,000 ac) of farmlands lost the winter wheat crop or were not planted in 2011, and about half of that land (mostly Weinbach silt loam, Karnak silty clay, Sciotoville silt loam, and Alvin fine sandy loam) (Parks and Fehrenbacher 1968) had significant soil damages, including land scouring and sediment deposition, or was slow to drain. Crater lakes, land scouring (figure 6), gullies, and sand deltas were created when the Len Small levee breached and removed agricultural land from production (Olson 2009; Olson and Morton 2012b). Most of the other farmland in Alexander County dried out sufficiently to permit planting of wheat in fall of 2011. It appears that all of Alexander County soils dried sufficiently by spring of 2012 to allow the planting of corn and soybeans. It is not clear how much 2011 farm income replacement came from flood insurance since not all Alexander County, Illinois, farmers had crop insurance. In addition, roads and state facilities were impacted by floodwaters which passed through the Len Small breach.

Illinois agricultural statistics recorded that 1,800 fewer ha (4,500 ac) of corn and 2,600 less ha (6,500 ac) of soybeans were harvested in Alexander County in 2011 compared to 2010. The area produced 1,570,000 bu of corn in 2010 but only 710,000 bu in 2011. The soybean production level was 1,200,000 bu in 2010 but dropped to 865,000 bu in 2011 due to flooding, crop, and soil damage. The floodwaters also scoured the agricultural lands in some places and deposited sand at other locations.

FLOODING OF PUBLIC AND PRIVATE BOTTOMLANDS WITH AND WITHOUT LEVEE PROTECTION IN WESTERN ALEXANDER COUNTY, ILLINOIS

All bottomlands north of the confluence between the Mississippi River and the western Alexander County levees with an elevation of less than 100.7 m

(332 ft) above sea level were flooded when the Mississippi River backed up. Approximately 24,000 ha (60,000 ac) of public and private alluvial lands, both levee protected and without levees, were flooded along the east and north sides of the Mississippi River (figure 1) between mile markers 12 and 39. The 1957 to 1963 soil maps of the area show alluvial soils consisting of recently deposited sediment that varies widely in texture (from clay to sand) with stratified layers. The natural vegetation on these alluvial bottomlands ranges from recent growth of willows (*Salix* L.) and other plants to stands of cottonwood (*Populus deltoides* L.), sycamore (*Platanus occidentalis* L.), and sweet gum (*Liquidambar styraciflua* L.).

The map (figure 1) shows the public and private lands of the southwest Alexander County, Illinois, area that were impacted by the flood of 2011. Approximately one third of the area (8,000 ha [20,000 ac]) is in public lands, including uplands (the Shawnee National Forest and Santa Fe Hills) and bottomlands (Burnham Island Conservation, Horseshoe State Conservation area, Goose Island, Big Cypress, and the land adjacent to the Len Small and Fayville levees). The unleveed bottomlands and public conservation areas sustained flood damage but were more resilient than the private agricultural and urban lands inside the levees. The Mississippi bottomlands are riparian forests (transition ecosystems between the river and uplands) with fertile, fine textured clay or loam soils that are enriched by nutrients and sediments deposited during flooding (Anderson and Samargo 2007). Bottomlands that experience periodic flooding have hydrophytic plants and hardwood forests that provide valuable habitat for resident and migratory birds. The Illinois Department of Natural Resources has an extensive research program monitoring migratory birds and waterfowl at Horseshoe Lake. Although these alluvial river bottomland species are well adapted to periodic flood cycles which can last several days to a month or more (Anderson and Samargo 2007), the impact of the 2011 flood duration (2 to 4 weeks) on these wetlands habitat and woodlands has not been assessed.

Figure 7

A farmstead protected by a farmer-built levee.

There are a number of towns and villages in western Alexander County, including Olive Branch, Miller City, and Cache. Floodwaters covered roads and railroads and damaged some bridges, homes, and other building structures. In western Alexander County, floodwater destroyed 25 Illinois homes and damaged an additional 175 homes and building structures located on Wakeland silt loam and Bonnie silt loam soils (Parks and Fehrenbacher 1968) or similar alluvial floodplain soils. The Olive Branch area (figure 1) was one of the hardest hit according to Illinois Emergency Management Agency.

Agricultural and forest lands on the riverside of the Len Small levee are not protected from flooding and store significant amounts of floodwater with minimal damage to the crops such as soybeans, which can be planted later in the spring or early summer. This farmland was under water prior to planting for the entire months of April and May, 2011. After both the Ohio and Mississippi rivers dropped and drained by late June of 2011, these fields were planted to soybeans. Late May and early June is the normal planting time for soybeans in the area, so a small soybean yield reduction was noted.

REPAIR OF LEN SMALL LEVEE IN WESTERN ALEXANDER COUNTY

In the fall of 2011, local farmers and members of the Len Small Levee District patched the Len Small levee. They created a sand berm 1 m (3 ft) lower than the original levee. They hoped the USACE would cover the levee with a clay cap and restore it at least to the original height. The USACE agreed to do this in August of 2012 after receiving additional funds from Congress. The project was completed in 90 days. Some individual farmers created berms around their farmsteads (figure 7) to protect their farmsteads from any future flooding that might occur.

In June of 2012, the USACE received US$802 million in emergency Mississippi River flood-repair funding for up to 143 high-priority projects to repair levees, fix river channels, and repair other flood-control projects in response to the spring of 2011 flood, which set records from Cairo, Illinois, to the Gulf of Mexico. Both the Birds Point–New Madrid Floodway levee repair and the Cairo area restoration projects were high on the list with the USACE targeting US$46 million to repair the damage to Cairo area, including the Alexander County area flood-control systems (Camillo 2012; Olson and Morton

2012a, 2012b). Improvements were completed throughout Alexander County, including work on pump stations, drainage systems, and small levees, some of which failed in April of 2011. These projects were funded by the county matching funds with the USACE and a combination of grants from the Delta Regional Authority and the State of Illinois (Koenig 2012). The creation of a larger drainage system running through northern Alexander and Union counties included large culverts and levees designed to better protect Illinois communities such as East Cape Girardeau, McClure, Gale, and Ware, and help keep water from collecting in low-lying bottomland areas.

CONCLUSIONS

In 2011, the record Ohio River flood resulted in the USACE blasting open the Birds Point levee fuse plug as waters reached a critical height on the Cairo gage. However, this unprecedented flood level at the confluence put tremendous pressure on and under the Mississippi levees to the north in western Alexander County. The delay in the decision to blow up the Birds Point fuse plugs and frontline levees had significant consequences for rural Illinois landowners, farmers, and residents in Alexander County near the Len Small levee that failed the morning of May 2, 2011, at a time when the peak flow on the Ohio River caused the Mississippi River water to back up many kilometers to the north. Local flooding and damage to building structures, crops, and soils initially occurred in late April of 2011when the Ohio River at flood stage poured through the Post Creek cutoff and a previously unrepaired Karnak levee breach and rushed to the west through the middle Cache River valley. Consequently, the town of Olive Branch would have flooded even if the Len Small breach had not occurred. The Len Small levee situation does not seem to have been a factor in the USACE decision-making process or have affected the time of the opening of the Birds Point–New Madrid levee fuse plug. The USACE did consider the need to protect the Cairo mainline levee and floodwall and the Commerce to Birds Point main line levee from a breach, as well as potential impact on landowners in the Birds Point–New Madrid Floodway. The mega sand boil in Cairo, the heavy local rains on May 1st in the Mississippi River watershed, and the new peak forecast of 19.2 m (63.5 ft) on the Cairo gage proved opening the Floodway was the correct decision. The frontline Commerce to Birds Point levee did not fail, and more than 1 million ha (2.5 million ac) of agricultural bottomlands in Missouri Bootheel and Arkansas were protected from flooding. Even if the Birds Point–New Madrid levee had been opened four days sooner at a time when the record level floodwaters were 1.3 m (4 ft) lower, the prolonged record Mississippi River floodwater levels and pressure on the Len Small levee, which continued for weeks, would likely have still resulted in the Len Small levee breach a few days later.

ACKNOWLEDGEMENTS

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CERTIFICATE OF SERVICE

I hereby certify that on July 3, 2014, I electronically filed the Declaration of Nicholas Pinter, Ph.D. in Support of Plaintiffs' Motion for Preliminary Injunction and Exhibits 1, 2 and 3 thereto with the Clerk of the Court using the CM/ECF system which will send notification of such filings to all registered counsel participating in this case. There are no non-registered participants in this case.

Respectfully submitted,

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IN THE UNITED STATES DISTRICT COURT
FOR THE SOUTHERN DISTRICT OF ILLINOIS

NATIONAL WILDLIFE FEDERATION, PRAIRIE RIVERS NETWORK, MISSOURI COALITION FOR THE ENVIRONMENT, RIVER ALLIANCE OF WISCONSIN, GREAT RIVERS HABITAT ALLIANCE, and MINNESOTA CONSERVATION FEDERATION, Plaintiffs, vs. UNITED STATES ARMY CORPS OF ENGINEERS; LT. GENERAL THOMAS P. BOSTICK, Commanding General and Chief of Engineers, LT. GENERAL DUKE DELUCA, Commander of the Mississippi Valley Division of the Army Corps of Engineers, Defendants.	CASE NO. 14-00590-DRH-DGW **REPLY DECLARATION OF NICHOLAS PINTER, Ph.D. IN SUPPORT OF PLAINTIFFS' MOTION FOR PRELIMINARY INJUNCTION** HEARING: TBD TIME: TBD

I, Nicholas Pinter, declare as follows:

1. The facts set forth in this Declaration are based upon my personal knowledge. If called as a witness, I could and would testify to these facts. As to those matters that present an opinion, they reflect my professional opinion and judgment on the matter. I make this Declaration in support of plaintiffs National Wildlife Federation *et al*.'s reply memorandum of points and authorities in support of their motion for preliminary injunction halting construction of any new river training structures as part of the U.S. Army Corps of Engineers' ("Corps'") management of the Upper Mississippi River System, including those planned as part of the Dogtooth Bend, Monsenthein/Ivory Landing, Eliza Point/Greenfield and Grand Tower projects.

2. I am a Professor in the Geology Department and Environmental Resources and Policy Program at the Southern Illinois University ("SIU"), and Director of the SIU's Integrative Graduate Education, Research and Training ("IGERT") program in "Watershed Science and Policy." I have over 20 years' experience in the fields of geology, geomorphology, fluvial geomorphology and flood hydrology. My qualifications, professional experience and background are set forth in my original June 24, 2014 (filed July 3) declaration ("Original Declaration" or "Pinter Declaration"), and Exhibit 1 thereto. Pinter Dec. ¶¶ 1-5 & Exh. 1.

<u>Documents Reviewed for this Declaration</u>

3. In preparing this Declaration, I reviewed the following documents in addition to the documents listed in paragraphs 6 and 7 of my original declaration: (1) Defendants' Opposition to Plaintiffs' Motion for a Preliminary Injunction ("Opposition Brief"), (2) the Declaration of Edward J. Brauer ("Brauer Declaration"), (3) the Declaration of Michael G. Feldman ("Feldman Declaration") and Attachments 1 and 2 thereto, and (4) the Declaration of Jody H. Schwarz in Support of Defendants' Opposition to Plaintiffs' Motion for a Preliminary Injunction ("Schwarz Declaration") and Exhibits 1 through 6 thereto.

<u>Analysis</u>

4. I was asked prior to preparing my Original Declaration to form an independent professional opinion as to whether building new river training structures, including those planned by the Corps in the Dogtooth Bend, Monsenthein/Ivory Landing, Eliza Point/Greenfield Bend and

Grant Tower projects, may pose a significant risk of irreparable harm to the natural environment and to people and the property of people who live, work, attend school and/or recreate in the floodplain, including by raising flood stage heights on the Mississippi River. As discussed below, my original conclusion remains the same after reviewing the Opposition Brief and the Brauer, Feldman and Schwarz declarations. I conclude that the Corps' proposed projects, and river training structures generally, *do* pose a significant risk of irreparable harm to the natural environment, human safety and human property. As discussed in detail below, neither the Corps in its Opposition Brief nor Mr. Brauer, Mr. Feldman or Ms. Schwarz in their declarations provides evidence that river training structures do *not* raise flood levels.

5. I was also asked prior to preparing this Reply Declaration to review the Feldman Declaration and, to the extent he discusses topics within my area of expertise, to form an independent professional opinion as to his claims regarding the benefits of river training structures and the costs of delaying or permanently tabling the Dogtooth Bend, Monsenthein/Ivory Landing and Eliza Point/Greenfield Bend projects. As discussed in detail below, I conclude after reviewing Mr. Feldman's Declaration that he overstates some of benefits of river training structures as well as the costs of delaying or permanently tabling the proposed the Dogtooth Bend, Monsenthein/Ivory Landing and Eliza Point/Greenfield projects.

A. The Information and Conclusions in My Original Declaration Remain Accurate and Unchanged.

6. As I attested in paragraph 9 of my Original Declaration, damages from floods worldwide have risen dramatically over the past 100 years (Munich Re Group, 2007). While much of this increase is due to economic development in floodplains (Pinter, 2005; Pielke, 1999), it is also clear that flooding itself has physically increased in magnitude and frequency on many rivers, including the Mississippi River. (Pinter et al., 2006a; Pinter et al., 2006b; Helms et al., 2002). Historical time series of stage data, which are unequivocally homogenous over time (Criss and Winston, 2008), show strong and statistically significant increases of flood heights on portions of

the Mississippi River over time. Neither the Corps in its Opposition Brief nor Mr. Brauer, Mr. Feldman or Ms. Schwarz in their declarations rebuts these facts.

7. As I attested in paragraph 10 of my Original Declaration, a number of processes can lead to flood magnification or otherwise alter flood response on a river. These include climate change, agricultural practices, forestry practices, urbanization and construction of other impervious surfaces, loss of wetlands, decreases in floodplain areas, construction and operation of dams, and modifications and engineering of river channels. The range of these changes can alter the volume and timing of runoff (discharge or flow of water) entering and moving through river systems. In addition, other natural or human-induced changes to river channels and their floodplains can alter the conveyance of flow within the river channel, resulting in increases or decreases in water levels (including flood stages) for the same discharge. Neither the Corps in its Opposition Brief nor Mr. Brauer, Mr. Feldman or Ms. Schwarz in their declarations rebuts these facts.

8. As I attested in paragraph 11 of my Original Declaration, the Mississippi River has been intensively engineered by the Corps over the past 50 to 150-plus years (depending on the reach), and some of these modifications are associated with large decreases in the river's capacity to convey flood flows. Numerous scientific investigations, including Corps reports, some dating back to the early 1900s or earlier, have noted large increases in flood levels in association with wing-dike construction. For example, investigators recognized as early as 1933 that "bankful [sic] carrying capacity [of the Missouri River] would be permanently reduced by existing works, such as dikes and revetments used in shaping and controlling the stream for modern barge transportation" (Hathaway, 1933 (quote); Schneiders, 1996 at 346 (same)). Harrison (1953) likewise found that at discharges greater than 50,000 cubic feet per second the "controlled [channel of the Missouri River] has [a] smaller capacity, having 35% less discharge at bankfull stage," one "principal reason" for which was the "increase in roughness" caused by "[t]raining dikes protruding into the flow." These findings that river training structures increase flood levels have been confirmed worldwide and are considered accepted knowledge elsewhere. In the Netherlands, for example, the government has begun modifying river training structures on the Rhine River to lower flood levels (U.S. Government Accountability Office, "Mississippi River: Actions Are Needed to Help Resolve

Environmental and Flooding Concerns about the Use of River Training Structures, December 2011; "GAO Report") at 41. To date, however, the Corps has never addressed in an EIS the vast body of peer-reviewed, independent research showing that river-training structures increase flood heights. *Id.* These facts are unrebutted by both the Corps in its Opposition Brief and Mr. Brauer, Mr. Feldman or Ms. Schwarz in their declarations.

9. The Corps and Mr. Brauer do both contend, however, that contrary to the weight of the published studies discussed above and below, the "results of . . . independent expert external reviews all lead to the conclusion that river training structure construction has *not* resulted in an increase in flood levels." Brauer Dec. ¶ 8 (emphasis added); Opposition Brief at 13. But Mr. Brauer fails to describe or cite to the alleged "external reviews," and thus provides no evidence on which to judge his assertion. Mr. Brauer also provides no evidence refuting, among other things, the aforementioned evidence discussed in Hathaway (1933) and Schneiders (1996) that "the carrying capacity of the [Missouri] river has been decreased so materially by the [river training] work that floods have occurred at such points as Waverly, Boonville and Hermann, Mo., at lower gauge readings with smaller volumes of water than the 1929 flood stage." Mr. Brauer asserts that Schneiders (1996) does not "draw any conclusions on the impact of river training structure construction on flood levels." Brauer Dec. ¶ 12. But his assertion is directly refuted by the quoted passage from Schneiders (1996). It is only by ignoring or improperly discrediting the evidence I have cited that Mr. Brauer is able to claim that none of the "additional 11 references cited by Dr. Pinter . . . would lead the Corps to a different conclusion on the impacts of river training structure construction on flood levels and public safety than what was established in the EAs." Brauer Dec. ¶ 13.

10. Mr. Brauer and the analysis in Appendix A to the environmental assessments ("EAs") for the Dogtooth Bend, Monsenthein/Ivory Landing and Eliza Point/Greenfield projects are also wrong in concluding that 51 studies attached to the comments of the National Wildlife Federation, Izaak Walkton League of America, Missouri Coalition for the Environment, Prairie Rivers Network and Sierra Club on the draft EAs, including many of my own studies, do *not* "support[] the conclusion that flood levels have . . . been increased as a result of construction of

river training structures." Brauer Dec. ¶ 9. For example, in discrediting many of "the 51 studies provided to the Corps" as only discussing "flow frequency, physical modeling and model scale distortion [or] levee construction" rather than "the construction of river training structures and/or increases in flood levels," Mr. Brauer makes the unfounded and erroneous conclusion that any research study without "river training structure" in its title is not relevant to the effect of such structures on flood levels. Brauer Dec. ¶ 10. To the contrary, all of the topics covered by those studies are necessary for understanding the processes by which river training structures interact with flow and affect flood levels. Increases in flood frequency, for example, are merely a statistical transformation of – meaning they are essentially the same as – increases in flood levels. As discussed further below, Mr. Brauer is also wrong that the all of my research and others' studies that "link river training structures to an increase in flood levels" contains "[m]ajor errors" that "put[] into question [the studies'] conclusion that the construction of river training structures impacts flood levels and consequently public safety." Brauer Dec. ¶ 16.

11. As I attested in paragraph 12 of my Original Declaration, my research has looked extensively at the extent and causes of flood magnification, particularly on the Mississippi River. This research documents that climate, land-use changes, and river engineering have contributed to statistically significant increases in flooding along portions of the Mississippi River system. However, the most significant cause of flood height increases on the Middle Mississippi River and Lower Missouri River can be traced to the construction of wing dikes and other river training structures. Indeed, flood height increases on those river segments exceed by a factor of ten the largest possible flood-stage increases due to observed increases in climate-driven and land-cover-driven flow (e.g., Pinter et al., 2008). In addition, the large multivariate study by Pinter et al. (2010) identified the age, location, and extent of every large levee system added to the Mississippi-Lower Missouri system during the past century, documenting that levees do contribute some but not all of the observed flood-level increases on the Middle Mississippi and elsewhere (confirming modeling by Remo et al., 2009; see Exhibit 2 to my Original Declaration). As discussed further below, Mr. Brauer wrongly discredits my research and others' studies that reach similar conclusions for having allegedly "[m]ajor flaws," including "use of inaccurate early discharge," "use of

estimated daily discharge data," "statistical errors," "not counting for other physical changes within the channel," and "the use of non-observed interpolated synthetic data points."

12. As I attested in paragraph 13 of my Original Declaration, recent theoretical analysis has shown that increased flood levels caused by wing-dike construction are "consistent with basic principles of river hydro- and morphodynamics" (Huthoff et al., 2013). This study concluded that even with extremely conservative parameters used in modeling, "the net effect of wing dikes will be higher flood levels." *Id.* Mr. Brauer criticizes Huthoff et al. (2013) as having "major errors" that "lead[] to incorrect conclusions on the magnitude of change in water surface by the author." Brauer Dec. ¶ 22. Mr. Brauer is not only wrong, he overstates his own criticisms in his (Brauer and Duncan) comment letter to Journal of Hydraulic Engineering, in which Huthoff et al. (2013) was published after peer review. Huthoff et al. (2013) presents fluid dynamical calculations showing that increases in flood levels are consistent with wing-dike construction in river channels. Brauer and Duncan submitted a comment letter to the journal suggesting that Huthoff et al.'s method was "oversimplified" and "simplistic," on which Mr. Brauer bases his criticism of the paper in his declaration. Huthoff et al., however, have submitted for publication a detailed rebuttal of Brauer and Duncan's critique, concluding that "reasonable assumptions *do* lead to significant surcharges [stage increases due to wing dikes] . . . and Huthoff et al. (2013) reach the modest conclusion that wing-dike-induced stage increases 'are consistent with basic principles of river hydro- and morphodynamics'" (Huthoff et al., 2014, submitted) (emphasis added).

13. As I attested in paragraph 14 of my Original Declaration, the theoretical analysis of Huthoff et al. (2013) is supported by empirical studies that have utilized hydrologic analyses; rigorous statistics; geospatial analyses; and 1D, 2D, and 3D hydraulic modeling to confirm, empirically as well as theoretically, the potential for significant increases in flood levels in response to the dense emplacement of wing-dike structures, such as employed on the Middle Mississippi River. Among this body of research, my research group was funded by the National Science Foundation to construct two large river-related databases to rigorously test for trends in flood magnitudes over time on over 4000 kilometers (over 2400 miles) of the Mississippi and Missouri

Rivers, and to quantify the impacts on flood levels from each unit of channel and floodplain infrastructure construction or other change.

14. As I attested in paragraph 15 of my Original Declaration, our hydrologic database consists of more than 8 million discharge and river stage values, including new synthetic discharges generated for 41 stage-only stations. This hydrologic database was used to test for significant trends in discharges, stages, and ‘‘specific stages.’’ We also conducted an extensive review of the validity of using discharge data taken from different types of measurement devices (float meters vs. other types of meters). Pinter (2010) tested whether it was appropriate to utilize older discharge measurements by examining 2150 historical discharge measurements digitized from the three principal stations on the Middle Mississippi River ("MMR"), including 626 float-based discharges and 1516 meter-based discharges, and including 122 paired measurements. All statistical tests we performed demonstrated that it was appropriate to utilize both older historical discharge data and newer discharge data as those different types of measurement tools produced accurate discharge measurements.

15. Mr. Brauer asserts that our conclusion in Pinter (2010) that older and newer discharge data alike produce accurate discharge measurements is invalid because "Pinter (2010) fails to go further in comparing [the pre-1933 discharge measurements] with the post-1933 [U.S. Geological Survey ('USGS')] data to confirm that the two data sets can be used together." Brauer Dec. ¶ 18. Mr. Brauer misrepresents Pinter (2010). The explicit purpose and methodology of the paper was to compare float-based discharge measurements with meter-based measurements, which the Corps has repeatedly singled out as the source of purported bias in the older discharge measurements.

16. Mr. Brauer further contends that "[e]arly discharge data collected before the implementation of standard instrumentation and procedures by the USGS in 1933 has been proven to be inaccurate (Ressegieu 1952, Dyhouse 1976, Dyhouse 1985, Dieckmann and Dyhouse 1998, Huizinga 2009, Watson el al. 2013a)." Brauer Dec. ¶ 18 (quote); Opposition Brief at 14 (same). Mr. Brauer is wrong. None of these sources prove that early discharge measurements – measurements made by the Corps' St. Louis District – are incorrect. To the contrary, and as

outlined above, Pinter (2010) completed a detailed statistical analysis of side-by-side measurements (using velocity meters as well as floats, which is the point of contention here) and found that the early measurements are as reliable as and fully comparable with the later measurements. This conclusion reiterates the conclusions of a study in the 1970s by the Corps itself (Stevens, 1979). Mr. Brauer's purportedly dispositive citations are not analyses and provide little or no new information on this subject. Ressegieu (1952) is an internal Corps memo. Dyhouse (1976) is an opinion letter critiquing an academic study. Dyhouse (1985) is an unpublished opinion article, without any analysis. Dieckmann and Dyhouse (1998) is an intergovernmental presentation that that asserts flaws in early discharges without any supporting evidence. Huizinga (2009) and Watson et al. (2013) are both Corps-funded studies that question early discharge values without providing evidence that they are invalid. Pinter (2014) details thorough responses to Watson et al. (2013) demonstrating its shortcomings.

17. Mr. Brauer's focus on and criticism of our use of pre-1933 discharge data is further undermined by the fact that the large majority of the 67 stations analyzed in Pinter et al. (2008, 2010) utilized only the later, post-1933 USGS discharge values. Analyses of these numerous USGS-only measurement gages show stage increases fully consistent with gages consisting of both early and later measurements.

18. In addition to Mr. Brauer's erroneous claims that much of our hydrologic data is too early to be accurate, he also wrongly contends that our hydrologic database and subsequent analyses are flawed because they "use . . . daily discharge data" and data "fabricated using interpolation schemes." Brauer Dec. ¶¶ 19 (first quote), 20 (second quote); Opposition Brief at 14 (same). I rebut each of these two erroneous claims in turn below.

19. Mr. Brauer asserts that a "major error in Dr. Pinter's analyses is the use of daily discharge data." Brauer Dec. ¶ 19. Our use of daily discharge data is not in error. Daily discharge values are published and used by the Corps, USGS and many other agencies and scientists worldwide, and are the accepted technical standard for a wide range of analyses and modeling, including by the Corps. With specific respect to their use in determining flood-level trends, daily discharge values (derived from daily stage measurements, combined with accepted rating curves)

produce the same overall results as do the much more limited number of direct measurements. Disqualifying all Corps and USGS daily discharge datasets as Mr. Brauer suggests would do *nothing* to prove that flood level trends have not increased. Instead of demonstrating some contrary trend, disqualifying these datasets would merely reduce the number of discharge values and thereby lower the statistical significance of the increasing flood level trends already found (see Pinter, 2014).

20. Mr. Brauer claims that a "majority of the hydrologic data" in our hydrologic database "(data at 49 of the 67 stations on the Mississippi River and Lower Missouri River) were fabricated using interpolation schemes developed by Jemberie et al. (2008), and they are not real data points." Brauer Dec. ¶ 20. Mr. Brauer misrepresents the data used in Jemberie et al. (2008). That study created a numerical algorithm for utilizing nearby stations and the year-to-year pattern of hydrologic behavior in order to interpolate the shape of trends for the largest flows, which occur only every few years. As Jemberie et al. (2008) makes clear, the overall trends and conclusions therefrom are determined only by the *measured* values in *large flood years*, which are most events for assessing the relationship between flood stage and river training structures. The *interpolations* based on measurements for smaller floods help suggest the likely patterns during the *intervening years*. Jemberie et al. (2008) also uses flow measurements from nearby stations to infer discharges during select years, which improves the accuracy of the overall data. For example, one station may lack direct flood measurements in 1940, but another station just a few miles upstream may have full measurements for that year. On a river as large as the MMR, neighboring sites have nearly identical flows. Jemberie et al. (2008) creates these neighboring discharge estimates by scaling each site proportional to its drainage basin area, and explicitly excluding any pair of measurement sites separated by a major tributary input. Jemberie et al. (2008) and its discharge data and estimates are methodologically sound. Mr. Brauer offers no specifics to show otherwise, or demonstrate any flaws in our use of the study's data.

21. As I attested in paragraph 16 of my Original Declaration, we developed a geospatial database alongside our hydrologic database. Our geospatial database consists of the locations, emplacement dates, and physical characteristics of over 15,000 structural features constructed along

the study rivers over the past 100 to 150 years. In developing this database we utilized: more than 4000 individual map and survey sheets; structure-history databases from six Corps Districts; databases from other agencies including the Coast Guard; and archival maps and surveys, all digitized and calibrated into a modern coordinate system and frame of reference. Within this database we parameterized 130 bridges, 54 dam structures, 25 artificial meander cut-offs, 1093 levees, and 13,231 wing-dam segments, among many other structures. Neither the Corps in its Opposition Brief nor Mr. Brauer, Mr. Feldman or Ms. Schwarz in their declarations disputes these facts.

22. As I attested in paragraph 17 of my Original Declaration, we used our hydrologic and geospatial databases together to generate reach-scale statistical models of hydrologic response. These models quantify changes in flood levels at each station in response to construction of wing dikes, bendway weirs, meander cutoffs, navigational dams, bridges, and other river modifications. Neither the Corps in its Opposition Brief nor Mr. Brauer, Mr. Feldman or Ms. Schwarz in their declarations disputes these facts.

23. As I attested in paragraph 18 of my Original Declaration, our analyses show that while climate and other land-use changes did lead to increased flows, *the largest and most pervasive contributors to increased flooding on the Mississippi River system were wing dikes and related navigational structures*. In contrast, large reaches of the Mississippi and Missouri Rivers with little or no dike construction showed *no* significant increases in flood levels. System-wide, the hydrologic pattern was that large-scale increases in flood levels occurred when and where large numbers of dikes and dike-like structures have been built. Progressive levee construction was the second largest contributor. While, as discussed elsewhere in this Declaration, the Corps and Mr. Brauer make several erroneous criticisms of our hydrologic data and analyses thereof, they do not contend that we did not make the stated conclusions from our analyses.

24. As I attested in paragraph 19 of my Original Declaration, our analyses demonstrate that wing dikes constructed downstream of a location were associated with increases in flood height ("stage"), consistent with backwater effects upstream of these structures. Backwater effects are the rise in surface elevation of flowing water upstream from, and as a result of, an obstruction to water

flow. These backwater effects were clearly distinguishable from the effects of upstream dikes, which triggered simultaneous incision and conveyance loss at sites downstream. On the Upper Mississippi River, for example, stages increased more than four inches for each 3,281 feet of wing dike built within 20 RM (river miles) downstream. These values represent parameter estimates and associated uncertainties for relationships significant at the 95 percent confidence level in each reach-scale model. The 95-percent level indicates at least a 95% level of certainty in correlation or other statistical benchmark presented, and is considered by scientists to represent a statistically verified standard. Our study demonstrated that the presence of river training structures can cause large increases in flood stage. For example, at Dubuque, Iowa, roughly 8.7 linear miles of downstream wing dikes were constructed between 1892 and 1928, and were associated with a nearly five-foot increase in stage. In the area affected by the 2008 Upper Mississippi flood, more than six feet of the flood crest is linked to navigational and flood-control engineering. While, as discussed elsewhere in this Declaration, the Corps and Mr. Brauer make several erroneous criticisms of our hydrologic data and analyses thereof, they do not contend that we did not make the stated conclusions from our analyses.

25. In addition, the Corps and Mr. Brauer wrongly contend that my Original Declaration is "fatally flawed" because I "discuss[] [my and others' research on] many rivers and river reaches [not on the MMR] in an attempt to imply that dikes on the MMR . . . are increasing flood levels." Opposition Brief at 14 (first quote); Brauer Dec. ¶ 24(a) (second quote). Different reaches of the Mississippi River do vary in some of their characteristics, but the same laws of physics apply to the MMR as to the other rivers and river reaches I discuss and allow for valid comparisons. Contrary to the Corps' and Mr. Brauer's opposite contention, understanding the impacts of Middle Mississippi River training structures can *not* be limited to looking only at the Middle Mississippi River. Understanding how different rivers and river reaches are managed (e.g., whether river training structures are used) and the resulting impacts from those management practices are *critical* to assessing how river training structures impact flood stage height. Our research and studies by other researchers show that while there are little or no increasing flood trends on stretches of the Mississippi and other rivers with few or no river training structures, there are large increases in

flood trends at locations (like on the MMR) where and at times when many new river training structures are built.

26. As I attested in paragraph 20 of my Original Declaration, more than 143 linear miles of wing dikes have been constructed on the Middle Mississippi River over the past 100 years (Remo and Pinter 2007; Remo et al. 2008). This represents about 3,960 feet of wing dikes per mile (or about 2,460 feet per kilometer) of channel. Wing dikes have also been heavily utilized on the Lower Missouri River, with over 383 linear miles constructed since 1890. This represents nearly 3,700 feet of wing dike per mile (or about 2,300 feet per kilometer) of channel in the Lower Mississippi River. These and similar river training structures are utilized to assist in river bank protection and stimulate channel scour which can reduce the amount of dredging required to maintain adequate navigation depths (e.g. COPRI 2012). Neither the Corps in its Opposition Brief nor Mr. Brauer, Mr. Feldman or Ms. Schwarz in their declarations rebuts these facts.

27. As I attested in paragraph 21 of my Original Declaration, the effects of wing dikes and other structures during flooding should not be confused with effects during periods of low flow. There is general agreement that during low in-channel flows, wing dikes lead to lowered water levels at most locations. This happens because the dikes cause channel incision, in which flow removes sediment from the stream bed and ultimately establishes a lower bed elevation. Channel incision is a process that has been well documented after dike construction in many (but not all) areas of the alluvial Mississippi and Missouri Rivers (e.g., Pinter and Heine 2005; Maher 1964). Neither the Corps in its Opposition Brief nor Mr. Brauer, Mr. Feldman or Ms. Schwarz in their declarations rebuts these facts.

28. As I attested in paragraph 22 of my Original Declaration, incision has caused water levels during periods of low flow (not floods) to decrease over time at the St. Louis, Chester, and Thebes measurement stations, as well as at other, intermediate locations. For all flood flows (flows equal to four or more times the average annual discharge level), however, water levels have increased *by three to ten feet or more* at all of these locations along the MMR. At Grand Tower, Illinois, water levels for just average flows have increased by almost three feet due to dike and weir construction. Near Grand Tower, bedrock underlies parts of the Middle Mississippi channel and

limits incision (Jemberie et al. 2008). The majority of these facts are unrebutted by both the Corps in its Opposition Brief and Mr. Brauer, Mr. Feldman or Ms. Schwarz in their declarations. However, as discussed and rebutted below, Mr. Brauer erroneously claims that there is no bedrock near the proposed Grand Tower project location. Brauer Dec. ¶ 24(g).

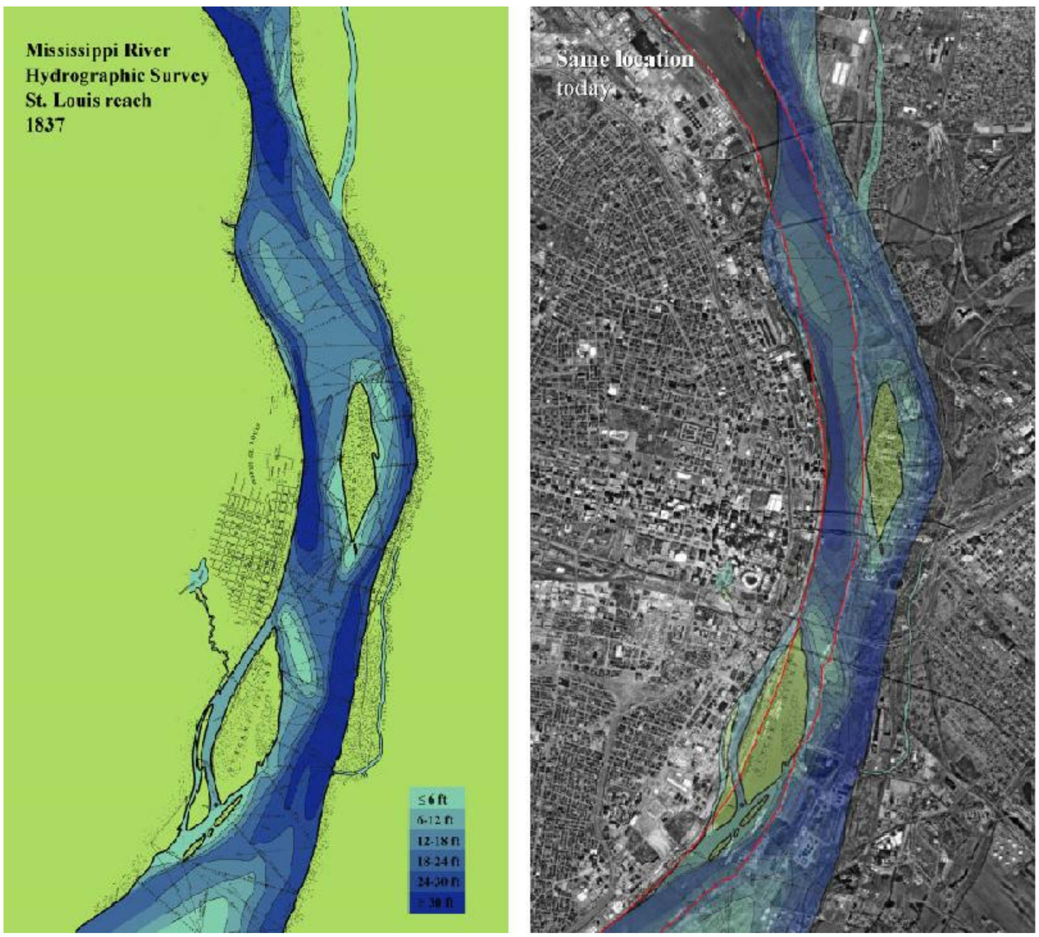
29. As I attested in paragraph 23 of my Original Declaration, many other studies confirm and corroborate these findings on the flow-dependent effects of river training structures. Particularly after the record-breaking floods on the Middle Mississippi, researchers sought to answer why such large increases in flood levels had occurred for the same discharges (volumes of flow) that had been observed in the past. (e.g., Belt 1975; Stevens et al. 1975). Since then, multiple studies involving hydrologic time-series analyses, statistical analyses, geospatial analyses, and hydraulic modeling have correlated the timing and spatial distribution of dike construction with increases in flood stages (e.g., Criss and Shock 2001; Wasklewicz et al. 2004; Jemberie et al. 2008; Pinter et al. 2008; Remo et al. 2009; Pinter et al. 2010, and others).

30. As I attested in paragraph 24 of my Original Declaration, wing dikes and other river training structures increase flood heights during high water because of the way they interact with river flow and the way they change the shape and form of the river channel. Since the beginning of historical "training" (engineering of the river to facilitate navigation) of the Mississippi and Missouri rivers, construction of dikes has narrowed large portions of these river channels to one-half or less of their original width. In addition, construction of dikes, bendway weirs, and other in-channel navigational structures has increased the "roughness" of the channel, leading to decreased flow velocities during floods.

31. Mr. Brauer responds by suggesting that I "may be referring to a river other than the MMR" in my statement that dike construction on the Mississippi and Missouri rivers has narrowed large portions of their channels to one-half or less of their original width. Brauer Dec. ¶ 24(c). I am not. And my original statement is correct. Wing dikes can reduce flow conveyance during floods and thereby increase flood levels either by reducing a river's cross-sectional area, by increasing the roughness of the channel or both. Extensive width reductions occurred on the MMR

during the late 19th and early 20th centuries, with little long-term change thereafter. As shown by Figure 1 below, some portions of the MMR were narrowed to half or less of their original width.

Figure 1. Mississippi River at St. Louis, as surveyed by Robert E. Lee in 1837 (left), and compared with the modern width of the channel (right). The original survey has been superimposed on the right panel. The current channel is shown by the red lines on the right panel. The red-lined channel boundaries shown in the right panel demonstrate that, indeed, this portion of the MMR is half or less the width today as it was in 1837. Historical channel geometry, including depths, digitized from original survey maps.



32. Mr. Brauer also asserts that although the MMR channel "has been narrowed due to river training structure construction," studies "have shown (Maher 1964, Biedenharn et al. 2000)" that "the cross sectional area of the deeper channel is preserved and the [channel's] ability to pass flow (conveyance) is the same or in some cases increased." Brauer Dec. ¶ 24(c). He claims that

"[f]ield data taken on the MMR have shown that the narrower and deeper channel will have the same cross sectional area and average velocity as before the placement of the structure." Brauer Dec. ¶ 14. But his assertion contradicts published analyses demonstrating that the actual response of the MMR to river training structures over time has been a reduction in both cross-sectional area and velocity during large flood events due to, among other things, increased channel "roughness" (e.g. Pinter et al., 2000; Remo et al., 2009). Mr. Brauer's contention that the MMR channel's conveyance has either remained the same or increased is true only for *small non-flood* flows.

33. As I attested in paragraph 25 of my Original Declaration, channel roughness is a measure of objects and processes that cumulatively resist the flow of water through a given reach of a river, including drag effects of sedimentary grains, bedforms (e.g., ripples and dunes on the bed), vegetation, turbulence, eddy circulation, and many others. A rough river bed exerts more resistance than a smooth river bed, resulting in slower flow of water. All other factors being equal, a flood that passes through a river reach with half the average flow velocity will result in average water depths that are double what they would otherwise be. Mr. Brauer claims that my "description of the relationship between velocity and depth" is "oversimplified and misleading" because in "rivers that are natural, compound channels, all factors are not equal." Brauer Dec. ¶ 24(d). But Mr. Brauer ignores the fact that the velocity-depth relationship I describe is a physical law of hydrodynamics. Before analyzing how other factors affect that relationship, it is essential to start with a description and understanding of first principles, which is precisely what I have done.

34. As I attested in paragraph 26 of my Original Declaration, recent modeling studies demonstrate the significant effects of river training structures during flood events on flow turbulence and large-scale vertical and horizontal eddy circulation (Huthoff et al., 2013). Other recent studies have focused on flow dynamics around submerged wing dikes and their impact on channel flow resistance (e.g., Yossef 2005; Yossef and de Vriend 2011; Azinfar and Kells 2011). These studies show that submerged wing dikes create flow mixing in their wake zones (e.g., Yossef 2005; Yeo and Kang 2009; Jamieson et al. 2011). These recirculating flows consume energy from the bulk flow field, causing increases in effective resistance near wing dikes and through wing-dike fields. The impact of wing dikes on flow resistance was quantified by Yossef (2004, 2005), whose

proposed relationship allows for an initial assessment of wing-dike impact on water levels (e.g., Azinfar 2010). According to Yossef's laboratory experiments, the effective cumulative hydraulic roughness of the bank zone relates to the size and longitudinal distance between the wing dikes.

35. Neither the Corps nor Mr. Brauer disputes that river training structures cause flow resistance. Brauer Dec. ¶ 24(e). Mr. Brauer does, however, contend that "the flow resistance is greatest at stages in which the dikes are the least submerged (stages below flood stages)." *Id*. Mr. Brauer's contention states his interpretation of hydraulic theory; in fact no laboratory, numerical, or field study has comprehensively tested if such a relationship exists or quantified how the depth of flow over overtopped dikes alters the effective resistance. Contrary to such theory, empirical studies show that the stage increases caused by new wing dike fields are proportionally greater for larger flows (e.g., Belt 1975; Criss and Shock 2001; Wasklewicz et al. 2004; Jemberie et al. 2008; Pinter et al. 2008; Remo et al. 2009; Pinter et al. 2010, and others). Additional data-based research is needed to reconcile hydraulic theory with observations. Reasonable hypotheses for the observed pattern include effects of flow velocity, which increases dramatically with increasing discharge, on net resistance. The Corps and Mr. Brauer consistently turn the scientific method on its head by beginning with a conclusion – the assumption that river training structures do not increase flood levels – and fashioning arguments to fit that assumption.

36. The Corps and Mr. Brauer also attempt to discount the applicability of a small subset of the studies demonstrating that river training structures increase channel roughness, reduce conveyance and increase flood stage levels on the grounds that they are "fixed bed physical flume studies (Azinfar and Kells 2009, 2008, 2007, and Azinfar 2010)." Brauer Dec. ¶ 23 (quote); Opposition Brief at 14. But they ignore the fact that experimental studies in controlled circumstances are still relevant evidence that river training structures can increase flood stage heights, along with hydrologic analyses, statistical analyses, geospatial analyses, fluid dynamical calculations, and 1D, 2D and 3D hydraulic modeling. Each of these types of research has its advantages and limitations, which is why accurate scientific synthesis looks at the conclusions from the full corpus of scientific research. Fixed-bed physical models are imperfect simulations of water flow over river training structures, but they are nonetheless relevant. Indeed, physical modeling

like that done in the Azinfar and Azinfar and Kells studies that the Corps and Mr. Brauer criticize as irrelevant is the *primary tool* used by the Corps' St. Louis District, albeit with a sedimentary bed, for the design and prototyping of all new river training structures.

37. As I attested in paragraph 27 of my Original Declaration, the role of river training structures in increasing flood heights is well recognized. For example, in the Netherlands, the impacts of wing dikes (navigational "groynes") on flood levels have both been recognized and taken into account in flood protection strategies. The government of the Netherlands recently completed a €45 million program to lower 450 wing dikes (groynes) on the Rhine system as part of its strategy to reduce flood levels.

38. Mr. Brauer questions the relevancy of the Dutch example to the Mississippi River, contending that the "structures used on the MMR are much different in size, spacing, and top elevation than those used by the Dutch." Brauer Dec. ¶ 24(f). Yet while Dutch groynes do differ from MMR dikes in some details, Mr. Brauer fails to cite a single study showing that the Dutch groynes are more likely to cause flood stage increases that the MMR dikes.

39. As I attested in paragraph 28 of my Original Declaration, changes in channel geometry and roughness related to river engineering tools employed for improved navigation and flood control appear to be the principal drivers behind changes in flood stage on the Mississippi River. The increases in flood stage are caused by both the direct effects of wing dikes, meaning interaction with flow, and the indirect effects of wing dikes, meaning the effects of the wing dike in changing the shape or form of the river bed. Hydrodynamic simulations of indirect and direct effects of wing dikes show decreases in velocity, increases in roughness, and corresponding increases in flood stage. Neither the Corps in its Opposition Brief nor Mr. Brauer, Mr. Feldman or Ms. Schwarz in their declarations specifically addresses paragraph 28 of my Original Declaration. I rebut elsewhere in this Declaration the Corps' and Mr. Brauer's general criticisms of my research and the other studies supporting my conclusion that river training structures increase flood stage heights and that the new dike construction projects here – at Dogtooth Bend, Monsenthein/Ivory Landing, Eliza Point/Greenfield Bend, and Grand Tower – will do the same and threaten public safety.

40. As I attested in paragraph 29 of my Original Declaration, river training structures constructed by the Corps to help maintain the nine-foot navigation channel have caused large-scale increases in flood levels, including increases of six to ten feet over broad stretches of the river where these structures are prevalent. Such large increases in flood heights in these rivers have occurred when and where – and only when and where – wing dikes, bendway weirs, and other river training structures have been built. These structures have led to significant increases in the frequency and magnitude of large floods. Neither the Corps in its Opposition Brief nor Mr. Brauer, Mr. Feldman or Ms. Schwarz in their declarations specifically addresses paragraph 29 of my Original Declaration. I rebut elsewhere in this Declaration the Corps' and Mr. Brauer's general criticisms of my research and the other studies supporting my conclusion that river training structures increase flood stage heights and that the new dike construction projects here – at Dogtooth Bend, Monsenthein/Ivory Landing, Eliza Point/Greenfield Bend, and Grand Tower – will do the same and threaten public safety.

41. As I attested in paragraph 30 of my Original Declaration, the projects now proposed on the Middle Mississippi River are particularly problematic for several reasons. First, as mentioned above, bedrock underlies parts of the Middle Mississippi channel near the Grand Tower project, which limits incision (Jemberie et al. 2008). In such locations, the ameliorating effect of new wing dikes in causing bed incision is reduced or eliminated, leading in the past to the largest observed increases in flood levels.

42. Mr. Brauer asserts that "[t]here is no support for the claim by Dr. Pinter" that there is bedrock underlying parts of the channel near the Grand Tower Project. Brauer Dec. ¶ 24(g). He contends that the "nearest bedrock formation (at an elevation capable of having an impact) to the Grand Tower work area is approximately five and a half miles upstream and over twenty miles downstream." *Id*. Mr. Brauer is wrong. Bedrock *is* present in this river reach, and it is alarming that the Corps' St. Louis District has designed and modeled (in their table-top physical model) the proposed new Grand Tower dikes in apparent ignorance of such a fundamental and important characteristic of the MMR channel. Specifically, historical surveys show that bedrock crops out at the channel-bottom surface, or in the shallow subsurface just beneath, forming a ledge along the

western margin of the channel around river mile ("RM") 68.7, and between RM 70.0-70.3 and RM 71.1-72.7 – *i.e.* through a significant portion of the Grand Tower project area. Mr. Brauer contends to the contrary that "bed samples taken in the Grand Tower reach confirm that the bed material is a combination of medium to coarse sands and pebbles up to one inch in diameter." *Id*. He is mistaken. In a river like the MMR, which transports an active sedimentary bed load at all times throughout its length, isolated channel grab samples will *always* yield sand and gravel, even on river reaches with an underlying bedrock substrate. Such samples in no way "confirm" that the channel is only underlain by sediment.

43. The presence of bedrock in the Grand Tower project area helps explain why observed flood stage increases have been so severe along this portion of the MMR. As discussed above, new wing dikes raise flood levels, but they also induce scour of the bed, which creates additional cross-sectional area within the central portion of the channel and reduces the net increases. However, where, as in the section of the MMR in the Grand Tower project area, a bedrock substrate inhibits scour, there is less or no cross-sectional area increase to reduce the flood stage increases. In these circumstances, the risk of large flood stage increases and the corresponding risk to public safety are at their peak.

44. As I attested in paragraph 31 of my Original Declaration, the new dike construction projects now proposed on the Middle Mississippi are also problematic because they threaten nearby levees that already have identified deficiencies. The Dogtooth Bend Project is immediately downstream of one of the sites where the Len Small levee failed during floods in 2011 (Dogtooth Bend EA at E2). This 5,000-foot breach yielded to fast-moving water that "scored farmland, deposited sediment, and created gullies and a crater lake" (K.R. Olson and L.W. Morton, "Impacts of 2011 Len Small levee breach on private and public Illinois lands," *Journal of Soil and Water Conservation*, Vol. 68:4, attached as Exhibit 3 to my Original Declaration). Neither the Corps in its Opposition Brief nor Mr. Brauer, Mr. Feldman or Ms. Schwarz in their declarations rebuts these facts.

45. As I attested in paragraph 32 of my Original Declaration, the proposed Grand Tower project spans approximately 7 River Miles along the Big Five Levee Drainage and Levee Districts,

including the Preston, Clear Creek, East Cape, and Miller Pond levees, together protecting over 49,000 acres of Illinois floodplain. The proposed Grand Tower wing dike project also lies just downstream of the Degognia/Fountain Bluff and Grand Tower Drainage and Levee Districts, protecting a further 56,000 acres. Currently, all segments of these levee systems have "Unacceptable" ratings following Corps inspections and assessment. The Dogtooth Bend Project likewise poses an unusually high potential for flood damage. The Cairo levee system ("Mississippi and Ohio Rivers Levee System at Cairo & Vicinity") is located a few miles downstream of the Dogtooth Bend Project. Although the greatest effects of wing dikes occur upstream, statistically significant increases in flood levels have also been identified downstream. Corps inspections have identified major deficiencies in the Cairo levee system, leading to its current "Unacceptable" rating in the National Levee Database. The majority of these facts are unrebutted by both the Corps in its Opposition Brief and Mr. Brauer, Mr. Feldman and Ms. Schwarz in their declarations.

46. The one thing in paragraph 32 of my Original Declaration that Mr. Brauer disputes is my conclusion that statistically significant increases in flood levels have also been identified downstream. Brauer Dec. ¶ 24(b). My conclusion is based on two of my published studies, Pinter et al. (2008) and (2010), which identify both large increases in flood levels *upstream* of new river training structures and smaller, but statistically significant, increases *downstream* of new structures. Mr. Brauer declares this to be impossible, but he bases his opinion solely on his interpretation of hydraulic theory, not any published research. In fact, turbulence and eddy circulation downstream of wing dikes represent a plausible mechanism for empirical increases in flood stages after dike construction. Mr. Brauer cannot wish away observed empirical trends based on his understanding of hydraulic theory.

47. As I attested in paragraph 33 of my Original Declaration, my work with local levee commissioners and other informed officials has revealed deep concern and widespread discussion about levee safety and performance during future floods, even without additional stresses. For at least the past decade, local stakeholders have repeatedly called for the St. Louis District of the Corps of Engineers to rigorously and independently assess the cumulative impacts of wing-dike construction in the Middle Mississippi River. Instead, a new wave of dike construction has been

undertaken, with each new project evaluated – perfunctorily – on an individual basis and without regard to cumulative effects. Neither the Corps in its Opposition Brief nor Mr. Brauer, Mr. Feldman or Ms. Schwarz in their declarations rebuts these facts.

B. Reply to the Feldman Declaration

48. As discussed in detail below, I conclude after reviewing the Feldman Declaration that Mr. Feldman overstates some of benefits of river training structures as well as the costs of delaying or permanently tabling the proposed the Dogtooth Bend, Monsenthein/Ivory Landing and Eliza Point/Greenfield projects.

49. Mr. Feldman asserts that "under the Upper Mississippi River Biological Opinion issued by the U.S. Fish and Wildlife Service and the Upper Mississippi River Restoration-Environmental Management Program, new river training structures are constructed for the purpose of providing environmental benefits for fish and wildlife." Feldman Dec. ¶ 4. Yet little or no benefit of river training structures to endangered fish species on the MMR has ever been demonstrated. The Corps has touted many of its navigational dike projects as having environmental benefits (*e.g.* DuBowy, P.J., 2012 and cover of same magazine issue), but rigorous monitoring has shown no actual species benefits associated with these activities (e.g., Papanicolaou et al., 2011).

50. Mr. Feldman claims that, "[a]s the Mississippi River is a dynamic system due to natural variances that affect sedimentation, impacts associated with delay of not awarding the contracts or constructing the features provided in those contracts will increase the length of that delay." Feldman Dec. ¶ 8. Mr. Feldman is mistaken that any large change in the Mississippi River's sediment flux or geomorphic conditions would occur if the proposed river training structure projects are delayed. For many decades, the Corps' St. Louis District has maintained the 9-foot navigation channel through dredging. In the absence of new river training structures, the Corps could continue to maintain the navigation channel through dredging. And outside factors being equal, no large change in the river's sediment flux would occur, nor, contrary to Mr. Feldman's conclusion, would there be any increased costs due to sediment accumulation.

51. Mr. Feldman contends that "[s]ignificant delays in awarding contracts and/or not constructing any new training structures will delay the overall Regulating Works Project completion date." Feldman Dec. ¶ 17. But in assuming that the construction of additional river training structures could eliminate the need for future dredging, Mr. Feldman ignores growing anecdotal evidence suggesting that recent river training structure construction is largely just *shifting locations* of the required dredging instead of *reducing* or *eliminating* the *long-term need* for dredging.

52. Mr. Feldman asserts that the "benefit to cost ratio for the Regulating Works Project construction completion is 18 to 1," and that the project "is one of the most valuable projects in the nation in terms of returns on investment." Feldman Dec. ¶ 17. But Mr. Feldman's claim is based on the erroneous assumption that new river training structures have zero impact on flood levels. As discussed thoroughly above and in my Original Declaration, and as document by Pinter et al. (2012), even small increases in flood levels cause large increases in flood risk that can overwhelm any purported cost-savings from reduced dredging. Furthermore, as just discussed, Mr. Feldman ignores the growing anecdotal evidence suggesting that recent river training structure construction is largely just shifting locations of the required dredging instead of reducing or eliminating the long-term need for dredging.

Conclusion

53. The new dike construction projects here – at Dogtooth Bend, Monsenthein/Ivory Landing, Eliza Point/Greenfield Bend, and Grand Tower – pose significant threats of increased flooding and flood risk. They are the latest manifestations of a flawed process that has allowed construction of hundreds of new dikes and dike-like structures that are causing elevated flood stages throughout the Middle Mississippi River. Unless these new dike construction projects are halted to allow their reconsideration based on a comprehensive and independent Supplemental Environmental Impact Statement that takes the foregoing studies and analyses into consideration, needless and potentially severe flooding will likely occur. The costs of halting the projects would be much less than Mr. Feldman claims in his declaration. Indeed, halting the projects would

significantly reduce taxpayer expenditures – along with societal and environmental hardship – by reducing long-term flood risk and flood damages.

54. I declare under penalty of perjury that the foregoing facts are true of my personal knowledge, that the foregoing expressions of professional judgment are honestly held in good faith, that I am competent to and if called would so testify, and that I executed this declaration on August 13, 2014 in Chicago, Illinois.

Nicholas Pinter

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Nicholas Pinter, Ph.D

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CERTIFICATE OF SERVICE

I hereby certify that on August 13, 2014, I electronically filed the Reply Declaration of Nicholas Pinter, Ph.D. in Support of Plaintiffs' Motion for Preliminary Injunction with the Clerk of the Court using the CM/ECF system which will send notification of such filings to all registered counsel participating in this case. There are no non-registered participants in this case.

Respectfully submitted,

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Attachment C
Comments of the National Wildlife Federation

Studies Linking the Construction of Instream Structures to Increases in Flood Levels

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Attachment D
Comments of the National Wildlife Federation

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- Supplemental Environmental Impact Statement (SEIS)

Proposed

The following maps show the locations of proposed river training structures. These designs are preliminary and are subject to change. The purpose of these proposed structures is to reduce dredging and to stabilize the navigation channel in an environmentally sensitive, cost-effective manner. These engineered plans will be used to develop detailed drawings and specifications. They have not yet been advertised for construction and are not in any current contracts. Review of these plans by the Corps, U.S. Fish and Wildlife Service, state agencies, and other stakeholders is ongoing.

⊟ Mississippi River

RM 155.4L - Construct Chevron
RM 155.3L - Construct Chevron
RM 155.2L - Construct Chevron
RM 155.1L - Construct Chevron
RM 154.9L - Remove Dike
RM 154.6L - Notch Dike
RM 154.4R - Construct Chevron
RM 154.3R - Construct Chevron
RM 154.2R - Construct Chevron
RM 154.0R - Remove Dike
RM 153.6L - Notch Dike
RM 153.2L - Construct Chevron
RM 153.0L - Notch Dike
RM 152.5L - Notch Dike

RM 152.2L - Construct Chevron
RM 152.1L - Construct Chevron
RM 152.0L - Notch Dike
RM 151.5L - Construct Chevron
RM 151.3L - Notch Dike
RM 132.6R - Notch Dike
RM 80.6L - Construct Dike
RM 73.6L - Construct Chevron
RM 72.9L - Extend Existing Dike
RM 72.5L - Construct Chevron
RM 66.7R - Dike
RM 61.6R - Construct Hard Point
RM 61-60 - Revetment
RM 59.6R - Notch Dike
RM 60-59 - Alternating Hardpoints and Revetment
RM 58.7R - Notch Dike
RM 58.2R - Notch Dike
RM 57.9R - Notch Dike
RM 56.5R - Construct Chevron

RM 25.7R - Restore Dike
RM 25.5R - Hard Points
RM 25.46R - construct Dike
RM 24.8R - Notch Dike
RM 24.77R - Hard Points
RM 24.76R - Construct Dike
RM 24.75R - Construct Dike
RM 24.7R - Construct Dike
RM 21.1L - Extend Existing Dike
RM 16.2R - Construct Chevron
RM 16.0R - Rootless Dike
RM 15.8R - Construct Chevron
RM 15.4R - Dike Extension
RM 15.1R - Dike Extension
RM 14.9R - Dike Extension
RM 14.7R - Dike Extension
RM 10.30L - Remove Dike
RM 10.10L - Notch Pile Dike
RM 10.10L - Remove Dike
RM 10.05L - Construct Dike
RM 7.90L - Remove Dike
RM 3.0L - Construct Dike
RM 2.6R - Construct Weir
RM 2.5R - Construct Weir
RM 2.3R - Construct Weir
RM 2.2R - Construct Weir

⊞ Illinois River

Responses to April 9, 2015 National Wildlife Federation Comments

Comment 1: *The Phase V EA is deficient because it fails to demonstrate a need for the proposed project...[T]he Phase V EA should provide the information outlined below:...*

> *(1) The specific history of dredging over the past 20 years (through a yearly breakdown of amounts and costs) within the two mile stretch of river covered by the proposed Phase V project.*

Response: Section 3 of the EA, Affected Environment, Socioeconomic Resources, has been updated to more clearly provide the dredging history for this particular reach of the river.

Comment 2: *The Phase V EA is deficient because it fails to demonstrate a need for the proposed project...[T]he Phase V EA should provide the information outlined below:...*

> *(2) An analysis of whether any of the dredging carried out in the two mile stretch during this 20 year history was the result of unique circumstances, such as the back to back 2011 flood and 2012 drought, and whether such unique circumstances are likely to re-occur.*

Response: The Mosenthein/Ivory Landing Phase 5 work area was chosen due to the history of chronic dredging in the reach. Dredging occurred 21 times over the past 20 years which includes following the 2011 flood and 2012 drought. Had the dredging in the reach been limited to years in which "unique circumstances" occurred, it is unlikely this work area would have been a priority over other chronic dredging locations. As with most dynamic systems, it is probable that unique circumstances will occur in the future.

Comment 3: *The Phase V EA is deficient because it fails to demonstrate a need for the proposed project...[T]he Phase V EA should provide the information outlined below:...*

> *(3) The number of times, if any, when navigation in the two mile stretch of river covered by the proposed Phase V project could not be maintained through dredging.*

Response: While there have not been any reports of groundings or hindrance to navigation in this reach in recent years, the long-term goal of the Regulating Works Project, as authorized by Congress, is to alleviate or eliminate the amount of annual maintenance dredging through the construction of river training structures to provide a sustainable navigation channel and reduce federal expenditures. See Section 3 of the EA, Affected Environment, Socioeconomic Resources, for dredging needs in this reach.

There is a risk associated with not constructing the work due to the Corps' ability to respond to extreme dredging situations as was encountered in the low water event of 2012/2013. To meet the dredging demand of that event, the Corps had to redirect O&M funding from other O&M needs as well as bring on an additional dredge boat. It is not a reliable plan to assume the availability of additional funding and additional dredging resources to deal with future extreme events.

For future low water periods, the funding and/or resources needed to maintain the authorized channel by the use of dredging alone may not be available. This is why it is imperative that the Corps continue to construct the Regulating Works Project with the proposed river training structures as planned. Should another low water event occur and the funding and additional dredge boat not be available, there could be significant impacts to the navigation industry and consumers.

Comment 4: *The Phase V EA is deficient because it fails to demonstrate a need for the proposed project...[T]he Phase V EA should provide the information outlined below:...*

> *(4) The projected future costs of required dredging under the no action alternative calculated for the full life of the proposed Phase V project, and an assessment of the ability to maintain navigation in the project area through dredging alone.*

Response: See responses to Comments 1 and 3 above and see revised Sections 3 and 4, Socioeconomic Resources, of the EA.

Comment 5: *The Phase V EA is deficient because it fails to demonstrate a need for the proposed project...[T]he Phase V EA should provide the information outlined below:...*

> *(5) The construction and full life cycle maintenance costs of the proposed Phase V project.*

Response: Due to Federal contracting laws and regulations, detailed government estimates for future contract work cannot be disclosed. See Section 4, Socioeconomic Resources, of the EA for a best estimate of the not-to-exceed cost for construction. The maintenance cost of a structure or set of structures is heavily dependent on year-to-year conditions on the MMR. Significant flood events, ice flows, and even barge impacts can contribute to the need for structure maintenance. The budget for Operation & Maintenance of the Regulating Works Project on the entire 195 river mile stretch of the MMR is approximately $3,000,000 in a typical year. It is not anticipated at this time that additional construction will lead to an increase in the annual Operation and Maintenance budget.

Comment 6: *The Phase V EA is deficient because it fails to demonstrate a need for the proposed project...[T]he Phase V EA should provide the information outlined below:...*

> *(6) The projected amount and costs of the dredging that will still be needed if the Phase V project is constructed.*

Response: Quantitative forecasts of dredging reduction as a result of the proposed action would be inappropriate given the dynamic nature of the MMR. Though the design process for river training structure configurations is geared toward identifying the alternative most likely to minimize the need for repetitive channel maintenance dredging (per the Project's authorization) while also taking into consideration environmental impacts, the need for repetitive channel maintenance is also heavily impacted by the MMR hydrograph and sediment loads from tributaries such as the Missouri River.

However, a review of two recent low water dredging seasons provides a quantitative look at the reduction of dredging as a result of the Regulating Works Project. During the 1988 dredge season, the river gage at St. Louis dropped below zero for 94 days. During this time, the Corps dredged approximately 19.1 million cubic yards of material to keep the channel open down to a stage of -4 ft on the St. Louis Gage. However, during the 2012 dredge season, the St. Louis Gage dropped below zero for 160 days. During this time the Corps dredged approximately 9.3 million cubic yards of material to keep the channel open down to a stage of -7 ft on the St. Louis Gage. Note that even though the river stayed below zero on the St. Louis Gage for much longer, and the channel was maintained to a greater depth, the 2012 dredge season showed over a 50% reduction in dredge quantities versus the 1988 dredge season. Also notable was a significant decrease in accidents within the navigation channel when comparing the 1988 and 2012 dredge seasons.

Comment 7: *The Phase V EA is deficient because it fails to demonstrate a need for the proposed project...[T]he Phase V EA should provide the information outlined below:...*

> *(7) The increased risks of upstream or nearby levee failures should the proposed project increase flood heights; and the projected costs of any needed repairs.*

Response: See response to Comment 22 below that the Corps does not believe that construction of new river training structures increases flood heights. Therefore, construction of the Mosenthein/Ivory Landing Phase 5 work area would not have any impact on upstream or nearby levees that needs to be discussed in the EA.

Comment 8: *The Phase V EA is deficient because it fails to demonstrate a need for the proposed project...[T]he Phase V EA should provide the information outlined below:...*

> *(8) The value of the ecosystem services that will be lost as a result of the Phase V project, which should be accounted for as a project cost.*

Response: Per the cited Final Interagency Guidelines for the Principles and Requirements for Federal Investments in Water Resources, published on December 24, 2014, "These Interagency Guidelines shall take effect 180 days after their date of publication in the Federal Register. Any Federal investments beginning after that date are expected to use the PR&G framework. Federal investment activities that are ongoing at the time these Guidelines take effect may also be evaluated using this new framework. Agency Heads, through their Agency Specific Procedures, will determine if such on-going activities should be analyzed using the PR&G." Accordingly, USACE is currently in the process of drafting Agency Specific Procedures for the PR&G. When USACE Agency Specific Procedures are implemented, the determination will be made as to the applicability of the Principles, Requirements, and Guidelines to the Regulating Works Project and specific work areas, as appropriate.

Comment 9: *The Phase V EA fails to evaluate a reasonable range of alternatives... Additional alternatives that should be examined include, but are by no means limited to:*

> *(1) Utilizing restoration measures to reduce sedimentation in the navigation channel and/or otherwise reducing the need for dredging the navigation channel.*
> *(2) Removing and/or modifying existing river training structures to reduce flood risks and restore backwater, side channel, and braided habitat.*
> *(3) Maintaining the authorized navigation channel through alternative approaches, including such things as alternative dredging strategies, and/or removing sediment dredged from the river rather than pumping dredged sediment back into the river adjacent to the main channel.*
> *(4) Minimizing the use of new structures, including by placing restrictions on the number and/or types of structures that can be utilized in a given reach based on a robust scientific assessment of the cumulative impacts of the various types of river training structures.*

Response: For the Mosenthein/Ivory Landing Phase 5 EA work area, the Corps considered all reasonable and feasible alternatives to meet the Regulating Works Project purpose as defined by Congress. See Section 2, Alternatives Including the Proposed Action, Development of Alternatives, for a detailed explanation of the alternative development process used by the Corps for the Phase 5 EA work area. Through this process the Corps determined that the only reasonable and feasible alternatives for this area would be to continue costly dredging in this area or to attempt to provide a more sustainable navigation channel through the construction of river training structures. While only the preferred river training structure alternative from the HSR Model Report was evaluated in detail in the Phase 5 EA, there were 16 different alternatives for various river training structure configurations considered by the Corps (the Phase 5 EA has been modified to note that the HSR Model Report is fully incorporated by reference and is part of the EA to clarify this). The Corps determined that the preferred alternative from the HSR modeling was the only alternative that needed to be fully evaluated in the Phase 5 EA because alternatives that did not adequately address the dredging issue and avoid or minimize environmental impacts were not deemed reasonable alternatives to consider further.

The suggestions provided in the comments for consideration of alternatives are for programmatic evaluation of the entire Regulating Works Project. The 1976 EIS addressed various alternatives at the programmatic level, and the pending SEIS will take into account the new information and circumstances since 1976 to fully discuss the reasonable and feasible programmatic alternatives for the Regulating Works Project. Therefore, the alternatives suggested are outside of the scope of the Phase 5 EA project purpose – to obtain and maintain the navigation channel with a focus of reducing costly dredging through the construction of river training structures.

Even still, the Corps did consider the alternatives recommended in the comments and came to the conclusion that these were not reasonable or feasible alternatives meeting the project purpose for the Mosenthein/Ivory Landing Phase 5 work area.

1. Congress has not provided authority to address sedimentation issues outside of construction of regulating works or dredging as part of the Regulating Works Project to obtain and maintain the navigation channel. Therefore, utilizing restoration

measures to reduce sedimentation in the navigation channel and/or otherwise reducing the need for dredging the navigation channel would not be a reasonable alternative.

2. Pursuant to 33 CFR § 336.1(c)(1), "[I]t is the Corps' policy to regulate the discharge of dredged material from its projects to assure that dredged material disposal occurs in the least costly, environmentally acceptable manner, consistent with engineering requirements established for the project." The Corps coordinates all dredge disposal with Federal and state resource agencies on a continual basis to ensure such disposal is done in an environmentally acceptable manner. The Corps continually evaluates dredging measures and disposal strategies. The current approach of dredging in the work area has been determined to be the most economically viable and environmentally acceptable option.
3. Removing, modifying, minimizing, or restricting construction of new river training structures would not meet the Project purpose. These measures could possibly be considered if the Corps deemed that compensatory mitigation was needed for the Phase 5 EA work area. However, the Corps has determined that no compensatory mitigation is needed because significant impacts have been avoided or minimized by the design of the river training structures.

Comment 10: [Paraphrasing from Pages 6-7 of the National Wildlife Federation comments: The Phase V EA fails to fully consider a less environmentally damaging alternative as required by law, regulation, and policy].

Response: The Phase 5 EA preferred alternative was the least environmentally damaging alternative of the 16 alternatives considered in the HSR Model Report that also adequately addressed the dredging issues in the work area. Section 2 of the EA, Alternatives Including the Proposed Action, has been expanded to more clearly articulate the alternative evaluation process.

Comment 11: *The Phase V EA relies on a fundamentally flawed and wholly unreliable HSR model. Because this flawed model drives the assessment of all hydrologic and habitat changes assessed in the Phase V EA, it makes the entire Phase V EA unreliable. . . . In addition, the HSR model can provide a non-predictive prototype only on a local basis and over short time scales.*

Response: The screening of alternatives using an HSR model is one of many steps in the river engineering process used to solve complex river engineering problems. Alternatives tested in the HSR model or other river engineering tools are initially developed by experienced river engineers using accepted river engineering guidance and practice. The alternatives considered are coordinated directly with all project partners including resource agencies, navigation industry, and other interested stakeholders to develop the recommended alterative. The recommended alternative proposed is then subject to technical review both within the District and Division before the final design.

HSR models have proven to be an effective tool to compare and analyze bathymetry and velocity trends of multiple alternatives. HSR model technology has been used successfully in solutions for over 50 complex sediment transport problems on 9 different rivers spanning 10 Corps districts. Monitoring of approximately 20 constructed projects has demonstrated the predictive capability of HSR models.

HSR modeling technology and projects developed using HSR models have gained recognition through numerous design awards from the Corps, environmental and navigation organizations and the engineering community. Projects developed using HSR models have been the subject of national and international technical papers and presentations including the PIANC Certificate of Recognition for following the "Working with Nature" philosophy by achieving our desired engineering outcome in conjunction with environmental considerations.

Comment 12: *This approach and the Phase V EA as a whole fail to recognize that this incremental approach in no way addresses system-wide changes to the Middle Mississippi River system. This model also cannot evaluate whether the new surge in construction of training structures in the past several years has simply shifted the loci of sedimentation which could eventually lead to even more river training structure construction.*

Response: The HSR model is one of many river engineering tools used in the development of alternatives to solve river engineering problems. Other tools and analyses are used (sometimes in conjunction with HSR models) to monitor the physical impacts of our structures including the near field and system wide impacts. These analyses include but are not limited to geomorphological studies (Munger et al., 1976, Brauer et al. 2005, Brauer et al. 2013), specific gage analyses (Munger et al. 1976, Watson and Biedenharn 2010, Huizinga 2009), reach evaluations, comprehensive survey analysis and dredging analyses.

Dredging data is periodically analyzed to determine the overall quantity of dredging necessary and the locations of the dredging. An evaluation of this data has shown that the construction of river training structures on the MMR has decreased the required dredging necessary to maintain a safe and dependable navigation channel (see response to Comment 6 above for information on dredging reduction as a result of the Regulating Works Project). As dredging quantity decreases, the need for river engineering solutions to reduce dredging will also decrease. It is important to note that river training structures are constructed on the MMR for purposes other than dredging reduction —these include environmental projects and projects to increase safety.

Comment 13: *In carrying out its hydrologic analysis the Corps should utilize the most up-to-date modeling to evaluate the potential impacts of each alternative such as by using state of the art two-dimensional and three-dimensional hydrodynamic models with inputs that recognize the current conditions in the river system.*

Response: The Corps has experience with a diverse collection of river engineering tools including large and small scale physical models and 1-, 2- and 3- dimensional numerical models. The selection of the river engineering tool(s) used to solve a problem is made by the engineers. The engineers have reviewed and analyzed multiple models and their applicability for addressing repetitive dredging concerns on the MMR. The use of an HSR model, which is a physical model that replicates the three-dimensional hydrodynamics and sediment transport of the river, was determined to be the appropriate tool in this work area by the engineers.

All models used to solve a river engineering problem are calibrated to the appropriate available data, which in most cases is recent data representing the most up to date condition of the river being studied. The model used to develop alternatives for the Mosenthein/Ivory Landing Phase 5 work area was calibrated to the most up to date hydrographic and velocity data available, representing the current conditions of the river.

Comment 14: *The Corps should abandon its use of micro models to evaluate the impacts of river training structures (including the Corps' Hydraulic Sediment Response or HSR model) as such models cannot be relied upon to provide accurate planning information as they lack predictive capability.*

Response: As discussed in the response to Comment 13 above, after an evaluation of all available river engineering tools, engineers from the Corps chose to use an HSR model to assist in selecting an alternative for the Mosenthein/Ivory Landing Phase 5 work area. Also see response to Comment 11 above on the justification of the use of the HSR model.

Comment 15: *The Phase V EA fails to adequately evaluate the extent and resulting fish and wildlife impacts of lost side channel habitats for at least the following four reasons. First, as noted above, the Corps relies on a flawed and non-predictive HSR model to conclude that side channel habitat will not be lost.*

Response: See response to Comment 11 above.

Comment 16: *The Phase V EA fails to adequately evaluate the extent and resulting fish and wildlife impacts of lost side channel habitats for at least the following four reasons... Second, the Phase V EA incorrectly assumes that the average planform width has remained relatively stable over the past four decades, and thus is no longer a key problem of concern for the river. However, this conclusion is contradicted by the information presented in the EA itself, which shows that the river has been losing an average of 4 feet of width each and every year since 1968: "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." EA at 10. And this is of course on top of the significant narrowing of the Mississippi River that occurred prior to 1968.*

Response: The statement that the planform has remained relatively steady is supported by the fluctuations in average planform width for the years between 1968 and 2011 around an average value. The Middle Mississippi River is in a state of dynamic equilibrium; some time periods between 1968 and 2011 showed an increase in width and others a decrease. For example, between 2003 and 2011 the planform widened by 92 feet (from 2,985 to 3,077) or 11.5 feet per year. The Corps' conclusions on overall planform impacts are supported by the data.

The major drivers of past planform changes are the loss and reduction of side channels and filling in of dike fields. Measures to preserve and enhance the side channels on the MMR have been successful in reducing the risk of planform narrowing from the loss of side channels. The combination of structure material, structure elevation and innovative structure designs has reduced the risk of dike field filling.

With the exception of weirs, which are constructed deep below the water surface, the structures being constructed as part of the Mosenthein/Ivory Landing Phase 5 work area are constructed at an elevation that is submerged regularly. The construction material and top elevation of the structures combined with the innovative design lead the District to believe that the construction of these structures will not lead to a decrease in planform width within the reach.

Comment 17: *The Phase V EA fails to adequately evaluate the extent and resulting fish and wildlife impacts of lost side channel habitats for at least the following four reasons... Third, while acknowledging a link between reduced stage at low flow and loss of side channel habitat (see EA at 14-15), the Phase V EA goes on to improperly conclude that the proposed project will not lead to additional losses of side channel habitat because "any impacts locally or cumulatively are being minimized through the use of innovative river training structures and through other District programs, which have currently seen success in restoring and preserving side channels affected by river training structures." EA at 15. This vague and self-serving conclusion is not, and cannot be, supported by any evidence and is contradicted by the well-recognized fact that river training structures lead to reduced stages at low flows (they raise stages when the river is at flood stage).*

Response: The District's conclusion that side channel habitat impacts are being minimized by the use of innovative river training structures and through District restoration programs is supported by recent information on the trends in side channel habitat in the MMR which shows overall improvements in side channel conditions. Appendix C of the EA, Cumulative Impacts Analysis, has been expanded to more clearly articulate this. With respect to the Mosenthein/Ivory Landing Phase 5 work area, innovative river training structures were used specifically to direct flow to the adjacent side channel to ensure that side channel habitat was not negatively impacted. The HSR model report has been updated to clarify the modeling process for identifying any anticipated impacts to the adjacent side channel. Information has also been added to the Environmental Consequences Section of the EA to more clearly articulate the conclusion that the work is not anticipated to result in the loss of side channel habitat.

Comment 18: *The Phase V EA fails to adequately evaluate the extent and resulting fish and wildlife impacts of lost side channel habitats for at least the following four reasons... Fourth, the Phase V EA essentially ignores the significant body of scientific evidence demonstrating the significant loss of side channel habitat in the Middle Mississippi River and the role of navigation-related activities, including the Regulating Works Project, in those losses. The EA also relies on the fact that revetment has been placed on the river banks to incorrectly conclude that additional side channel loss is not an issue of concern.*

Response: The EA clearly acknowledges the importance of side channels and side channel habitat and the Regulating Works Project's role in side channel impacts (e.g., see C-14 and C-17). The EA also clearly indicates that revetment restricts channel migration and eliminates the possibility of new side channels forming as a result of channel migration (see C-14 and C-21).

Comment 19: *The Phase V EA fails to provide any meaningful information on potential fish impacts and provides no information on potential wildlife impacts...The Phase V EA recognizes that the Corps has only the most extremely limited information upon which to draw any conclusions on fisheries impacts. Given the extensive amount of river training structure construction carried out by the Corps in the Middle Mississippi River, it is unacceptable that they have not done more research on the impacts of these structures on fish and wildlife resources. In the absence of this information, the Corps cannot draw any legitimate conclusions about the potential impacts of the proposed project on fish and wildlife.*

Response: This site-specific EA is tiered off of the 1976 EIS. In addition to the information on fish and wildlife impacts provided by the 1976 EIS, this site-specific EA incorporates and considers, as appropriate, new information on fish and wildlife impacts that have come about since 1976, as applicable to the work area (see Section 4, Environmental Consequences, Biological Resources, Fish and Wildlife). The cited 40 C.F.R. § 1502.22 which addresses incomplete or unavailable information applies "When an agency is evaluating reasonably foreseeable significant adverse effects on the human environment in an environmental impact statement..." The action covered by this site-specific EA is not anticipated to result in significant adverse effects on the human environment.

Comment 20: *The EA also fails to provide information on the habitat needs of species in the project area or how those needs might be affected by the project.*

Response: Section 3, Affected Environment, Biological Resources, and Section 4, Environmental Consequences, Biological Resources of the EA have been expanded to provide more information on habitat and associated impacts.

Comment 21: *The Phase V EA fails to properly evaluate the impacts to endangered species.*

Response: The EA and associated BA adequately and accurately evaluate the impacts to endangered species. See Section 4, Environmental Consequences, of the EA and the Fish and Wildlife Service's coordination letters in Appendix F, Agency and Tribal Government Coordination, including concurrence with the findings of our BA and Finding of No Significant Impact.

Comment 22: *Despite extensive peer-reviewed science demonstrating the role of river training structures in increasing flood heights, the Phase V EA continues to disagree with and attack this* *science. As a result, the Phase V EA does not effectively evaluate the significant risks to public safety created by river training structures in the Mississippi River and does not meaningfully evaluate alternative approaches to reducing those risks.*

Response: The Corps of Engineers considers public safety to be of paramount importance when designing and evaluating projects. The agency believes strongly that the best available science shows that this project will not increase flood heights, and consequently the project does not pose a significant risk to public safety. The Corps, other federal agencies and academic institutions have performed extensive research dating back to at least the 1930s on the physical effects of river training structures, including their impact on flood heights, and have concluded that river training structures do not raise flood heights. These evaluations have fully considered all available literature and science. In an effort to update this research, the Corps commissioned independent technical reviews to examine if river training structures had measureable impacts on flood stages within the Middle Mississippi River. The conclusions of the independent technical reviews reaffirmed that river training structures do not raise the stage of the river and do not increase flood risk. See Appendix A of the EA.

Comment 23: *In light of the significant risks to public safety posed by the Corps' ongoing objection to well settled science, National Wildlife Federation once again strongly urges the Corps to initiate a National Academy of Sciences study to evaluate this issue.*

Response: See response to Comment 22 above and Appendix A of the EA. The Corps recognizes that a few academics do not agree with the conclusions of the Corps, other federal agencies, and academic institutions. Due to the extensive research supporting the conclusions of the Corps, we do not believe that there is sufficient evidence to warrant funding costly and time-consuming research efforts at this time. The Corps welcomes and will participate in any independent reviews or research funded by an outside agency or organization that will further the science and understanding of the impacts of river training structures on flood heights.

Comment 24: *NWF urges the Corps to withdraw the Phase V EA and instead use the SEIS to evaluate the proposed Phase V project – and the Corps' other pending river training structure proposals.*

Response: The Corps does not believe that it is necessary to delay the Phase 5 work area while the SEIS is being prepared. As described in Section 1, Purpose of and Need for Action, Prior Reports, the Phase 5 EA has incorporated new information and circumstances relevant to the impacts of the action on the environment to the greatest extent possible. Should the analyses undertaken as part of the SEIS process reveal any new impacts on the resources, ecosystem, and human environment not accounted for in the EA, measures will be taken within the Corps' authority to avoid, minimize, and/or compensate for the impacts during that process as appropriate.

Comment 25: *The Phase V EA should also clearly document whether any actions proposed in the EA can be carried out under the existing authorization, or whether new authorization from Congress would be required.*

Response: The Corps' authority for the Regulating Works Project, including the Phase 5 work area, is described in detail in Section 1, Purpose of and Need for Action, accurately quoting and citing Congress' mandate on the purpose of the Regulating Works Project and how the Regulating Works Project is to be carried out. While Congress has not changed the purpose of the Project or how the Project is to be accomplished for the open channel of the Middle Mississippi River since the Rivers and Harbors Act dated January 21, 1927, Congress has continually appropriated line item funding for *new construction* of the Regulating Works Project from 1946 to the present date. As noted in Section 1, Purpose of and Need for Action, obtaining/constructing a sustainable navigation channel in the Middle Mississippi River is done through the construction of new revetment, new river training structures, rock removal, and construction dredging associated with the new revetment and new river training structures as mandated by Congress. The funding specifically appropriated and approved by Congress for construction of the Regulating Works Project is for this new construction work. The O&M funding identified by Congress beginning in 1980 for the Regulating Works Project is expended on items such as maintenance dredging; the costs associated with maintenance dredging; and modification, repair, replacement, and rehabilitation of existing revetment or river training structures. Congress' continued specific approval and authority of the new construction in the Regulating Works Project can be found in the following documentation:

P.L. 113-235; 128 Stat. 2130 (*See* H. Rpt. 113-486); P.L. 113-67; 127 Stat. 1165 (*See* H. Rpt. 113-135 and S. Rpt. 113-47); P.L. 112-175; 126 Stat. 1312 (*See* H. Rpt. 112-462 and S. Rpt. 112-164); P.L. 112-74; 125 Stat. 785 (*See* H. Rpt. 112-118 and S. Rpt. 112-75); P.L. 112-10; 125 Stat. 38 (*See* S. Rpt. 111-228); P.L. 111-85; 123 Stat. 2845 (*See* H. Rpt. 111-203; S. Rpt. 111-45; and Conf. Rpt. 111-278); P.L. 111-8; 123 Stat. 524 (*See* H. Rpt. 110-921; S. Rpt. 110-416; and House Appropriations Committee Print, Omnibus Appropriations Act, 2009 (H.R. 1105; Public Law 111-8, Division C – Energy and Water Development and Related Agencies Appropriations Act, 2009)); P.L. 110-161; 121 Stat. 1844 (*See* H. Rpt. 110-185; S. Rpt. 110-127; and House Appropriations Committee Print, Consolidated Appropriations Act, 2008 (H.R. 2764; Public Law 110-161, Division C – Energy and Water Development and Related Agencies Appropriations Act, 2008)); P.L. 110-5; 121 Stat. 8 (*See* H. Rpt. 109-474 and S. Rpt. 109-274); P.L. 109-103; 119 Stat. 2247 (*See* H. Rpt. 109-86; S. Rpt.109-84; and Conf. Rpt. 109-275); P.L. 108-447; 118 Stat. 2809 (*See* H. Rpt. 108-554 and Conf. Rpt. 108-792); P.L. 108-137; 117 Stat. 1827 (*See* H. Rpt. 108-212; S. Rpt. 108-105; and Conf. Rpt. 108-357); P.L. 108-7; 117 Stat. 11 (*See* H. Rpt. 107-681; S. Rpt. 107-220; and Conf. Rpt. 108-10); P.L. 107-66; 115 Stat. 486 (*See* H. Rpt. 107-112; S. Rpt. 107-39; and Conf. Rpt. 107-258); P.L. 106-377; 114 Stat. 1441 (*See* H. Rpt. 106-693; S. Rpt. 106-395; and Conf. Rpt. 106-988); P.L. 106-60; 113 Stat. 483 (*See* H. Rpt. 106-253; S. Rpt. 106-58; and Conf. Rpt. 106-336); P.L. 105-245; 112 Stat. 1838 (*See* H. Rpt. 105-581; S. Rpt. 105-206; and Conf. Rpt. 105-749); P.L. 105-62; 111 Stat. 1320 (*See* H. Rpt. 105-190; S. Rpt. 105-44; and Conf. Rpt. 105-271); P.L. 104-206; 110 Stat. 2984 (*See* H. Rpt. 104-679; S. Rpt. 104-320; and Conf. Rpt. 104-782); P.L. 104-46; 109 Stat. 402 (*See* H. Rpt.104-149 ; S. Rpt. 104-120; and Conf. Rpt. 104-293); P.L. 103-316; 108 Stat. 1707 (*See* H. Rpt. 103-533; S. Rpt. 103-291; and Conf. Rpt. 103-672); P.L. 103-126; 107 Stat. 1312 (*See* H. Rpt. 103-

135; S. Rpt. 103-147; and Conf. Rpt. 103-292); P.L. 102-377; 106 Stat. 1315 (*See* H. Rpt. 102-555; S. Rpt. 102-344; and Conf. Rpt. 102-866); P.L. 102-104; 105 Stat. 510 (*See* H. Rpt. 102-75; S. Rpt. 102-80; and Conf. Rpt. 102-177); P.L. 101-514; 104 Stat. 2074 (*See* H. Rpt. 101-536; S. Rpt. 101-378; and Conf. Rpt. 101-889); P.L. 101-101; 103 Stat. 641 (*See* H. Rpt. 101-96; S. Rpt. 101-83; and Conf. Rpt. 101-235); P.L. 100-371; 102 Stat. 857 (*See* H. Rpt. 100-618; S. Rpt. 100-381; and Conf. Rpt. 100-724); P.L. 100-202; 101 Stat. 1329 (*See* H. Rpt. 100-162; S. Rpt. 100-159; and Conf. Rpt. 100-498); P.L. 99-500; 100 Stat. 1783 (*See* H. Rpt. 99-670 and S. Rpt. 99-441); P.L. 99-141; 99 Stat. 564 (*See* H. Rpt. 99-195; S. Rpt. 99-110; and Conf. Rpt. 99-307); P.L. 98-360; 98 Stat. 403 (*See* H. Rpt. 98-755; S. Rpt. 98-502; and Conf. Rpt. 98-866); P.L. 98-50; 97 Stat. 247 (*See* H. Rpt. 98-217; S. Rpt. 98-153; and Conf. Rpt. 98-272); P.L. 97-377; 96 Stat. 1830 (*See* H. Rpt. 97-850 and S. Rpt. 97-673); P.L. 97-88; 95 Stat. 1135 (*See* H. Rpt. 97-177; S. Rpt. 97-256; and Conf. Rpt. 97-345); P.L. 96-367; 94 Stat. 1331 (*See* H. Rpt. 96-1093; S. Rpt. 96-927; and Conf. Rpt. 96-1366); P.L. 96-69; 93 Stat. 437 (*See* H. Rpt. 96-243; S. Rpt. 96-242; and Conf. Rpt. 96-388); P.L. 95-482; 92 Stat. 1603 (*See* H. Rpt. 95-1247; S. Rpt. 95-1069; and Conf. Rpt. 95-1490); P.L. 95-96; 91 Stat. 97 (*See* H. Rpt. 95-379; S. Rpt. 95-301; and Conf. Rpt. 95-507); P.L. 94-355; 90 Stat. 889 (*See* H. Rpt. 94-1223; S. Rpt. 94-960; and Conf. Rpt. 94-1297); P.L. 94-180; 89 Stat. 1035 (*See* H. Rpt. 94-319; S. Rpt 94-505; and Conf. Rpt. 94-711); P.L. 93-393; 88 Stat. 782 (*See* H. Rpt. 93-1077; S. Rpt. 93-1032; and Conf. Rpt. 93-1274); P.L. 93-97; 87 Stat. 318 (*See* H. Rpt. 93-327; S. Rpt. 93-338; and Conf. Rpt. 93-409); P.L. 92-405; 86 Stat. 621 (*See* H. Rpt. 92-1151; S. Rpt. 92-923; and Conf. Rpt. 92-1310); P.L. 92-134; 85 Stat. 365 (*See* H. Rpt. 92-381; S. Rpt. 92-327; and Conf. Rpt. 92-479); P.L. 91-439; 84 Stat. 890 (*See* H. Rpt. 91-1219; S. Rpt. 91-1118; and Conf. Rpt. 91-1456); P.L. 91-144; 83 Stat. 323 (*See* H. Rpt. 91-548; S. Rpt. 91-528; and Conf. Rpt.91-697); P.L. 90-479; 82 Stat. 705 (*See* H. Rpt. 90-1549; S. Rpt. 90-1405; and Conf. Rpt. 90-1788); P.L. 90-147; 81 Stat. 471 (*See* H. Rpt. 90-505; S. Rpt. 90-574; and Conf. Rpt. 90-820); P.L. 89-689; 80 Stat. 1002 (*See* H. Rpt. 89-2044; S. Rpt. 89-1672; and Conf. Rpt. 89-2216); P.L. 89-299; 79 Stat. 1096 (*See* H. Rpt. 89-527; S. Rpt. 89-632; and Conf. Rpt. 89-1163); P.L. 88-511; 78 Stat. 682 (*See* H. Rpt. 88-1479; S. Rpt. 88-1326; and Conf. Rpt. 88-1794); P.L. 88-257; 77 Stat. 844 (*See* H. Rpt. 88-902; S. Rpt. 88-746; and Conf. Rpt. 88-1027); P.L. 87-880; 76 Stat. 1216 (*See* H. Rpt. 87-2223; S. Rpt. 87-2178; and Conf. Rpt. 87-2531); P.L. 87-330; 75 Stat. 722 (*See* H. Rpt. 87-1125; S. Rpt. 87-1097; and Conf. Rpt. 87-1268); P.L. 86-700; 74 Stat. 743 (*See* H. Rpt. 86-1634; S. Rpt. 86-1768; and Conf. Rpt. 86-2181); P.L. 86-254; 73 Stat. 491 (*See* H. Rpt. 86-1152; S. Rpt. 86-486; and Conf. Rpt. 86-888); P.L. 85-863; 72 Stat. 1572 (*See* H. Rpt. 85-1864; S. Rpt. 85-1796; and Conf. Rpt. 85-2670); P.L. 85-167; 71 Stat. 416 (*See* H. Rpt. 85-552; S. Rpt. 85-609; and Conf. Rpt. 85-1049); P.L. 84-641; 70 Stat. 474, Ch. 490 (*See* S. Rpt. 84-2181 and Conf. Rpt. 84-2413); P.L. 82-504; 65 Stat. 616, Ch. 556 (*See* H. Rpt. 82-1652; S. Rpt. 82-1754; and Conf. Rpt. 82-2497); P.L. 82-203; 65 Stat. 616, Ch. 556 (*See* H. Rpt. 82-544; S. Rpt. 82-631; and Conf. Rpt. 82-1197); P.L. 81-759; 64 Stat. 595, Ch. 896 (*See* H. Rpt. 81-1797; S. Rpt. 81-1941; and Conf. Rpt. 81-2991); P.L. 81-355; 63 Stat. 845, Ch. 688 (*See* S. Rpt. 81-361 and Conf. Rpt. 81-1377); P.L. 80-782; 62 Stat. 1019, Ch. 655 (*See* H. Rpt. 80-1420; S. Rpt. 80-1167; and Conf. Rpt. 80-2319); P.L. 80-296, 61 Stat. 686, Ch. 411 (*See* H. Rpt. 80-723; S. Rpt. 80-710; and Conf. Rpt. 80-1110); P.L. 79-374, 60 Stat. 160, Ch. 247 (*See* H. Rpt. 79-1524; S. Rpt. 79-1057; Conf. Rpt. 79-1931); P.L. 79-24, 59 Stat. 39, Ch. 45 (*See* H. Rpt. 79-105; S. Rpt. 79-87; and Conf. Rpt. 79-352)

Comment 26: *The Phase V EA fails to properly evaluate – and account for – cumulative impacts.*

Response: The impacts of Corps O&M activities in support of navigation as well as a host of other factors affecting the human environment in the Mississippi River have been well documented for decades in a multitude of publications (including the 1976 Middle Mississippi River Regulating Works EIS). This understanding is clearly acknowledged and addressed in the EA as well as in the Cumulative Impacts Analysis (Appendix C). However, in order to more clearly address cumulative impacts, additional information has been added to Appendix C and information from other sources has been incorporated by reference.

Comment 27: *The Phase V EA fails to meaningfully evaluate the cumulative impacts of the Corps' many activities on the Mississippi River. These include the full suite of past, present, and reasonably foreseeable future Regulating Works Project activities, navigation operation and maintenance activities, flood damage reduction activities, and other reasonably foreseeable projects....For example, the Phase V EA fails to discuss the cumulative impacts of the existing river training [sic] located within the project area.*

Response: See Comment 9 above regarding incorporation by reference of the HSR model report. The HSR report provides a summary of existing river training structures and an analysis of planform changes in the work area. Reference to the HSR model study has been added to Section 3, Biological Resources, of the EA and to Appendix C.

Comment 28: *The Corps similarly appears not to have identified the full list of river training structures currently under construction or in planning for the Regulating Works Program.*

Response: Upon review and evaluation of the referenced website listing proposed river training structures, it was determined that this website was outdated and inaccurate and not indicative of the "reasonably foreseeable future" condition used to develop the list of structures in the Cumulative Impacts Analysis. For example, this outdated list contained dozens of ecosystem restoration structures proposed under the Navigation and Ecosystem Sustainability Program (NESP) which the District considers highly unlikely to receive funding in the reasonably foreseeable future. The website has been updated to more accurately reflect future construction. In addition, the list of reasonably foreseeable future structures in Appendix C (Table 3) has been updated to include new construction of ecosystem restoration structures to be implemented under the District's Biological Opinion Program.

Comment 29: *The Corps also carries out other major operations and maintenance activities that affect the Middle Mississippi River and the entire UMR-IWW, including: dredging and disposal of dredged material, water level regulation, construction of revetment, and operation and maintenance of the system's 37 locks and dams...*

In addition, the cumulative impacts analysis must evaluate the cumulative impacts of work carried out by the Corps under its flood damage reduction authority, including the construction and maintenance of Mississippi River levees and reasonably foreseeable future flood damage reduction projects...

The cumulative impacts analysis should also evaluate such things as past, present, and reasonably foreseeable future: (a) lock and dam construction; reservoir and dam operations that affect the Mississippi River and its floodplain – including for such facilities located in areas outside of the Mississippi River; (b) residential and commercial development, including road construction, that affects the Mississippi River and its floodplain; and (c) agricultural practices that have affected and will continue to affect floodplain wetlands and Mississippi River water quality.

In analyzing the cumulative effects of the activities discussed above, the Corps must compare the impacts to the historical, non-disturbed, Mississippi River and not compare the impacts to the current condition of the river. This includes both the historic ecological condition and the historical flow and flood level conditions. If this information is not currently available, the Corps must obtain this information unless the costs of doing so would be "exorbitant." 40 C.F.R. § 1502.22. To establish the proper baseline, the Phase V EA should document and evaluate the historical changes in the Mississippi River with respect to at least the following indicators:

- *Historical flows and flood levels;*
- *Acres of river and floodplain wetlands lost;*
- *Acres of native upland habitats lost;*
- *Miles of streambed lost or modified;*
- *Changes in stream flows;*
- *Changes in ground water elevations;*
- *Changes in the concentrations of indicator water quality constituents;*
- *Changes in the abundance, distribution, and diversity of indicator fish, waterfowl, bird, mammal, reptile, amphibian, and mussel communities;*
- *Changes in rainfall, and reasonably foreseeable future changes.*

Response: The Cumulative Impacts Analysis (Appendix C) has been updated to include the relevant requested information that is appropriate to include for this site-specific analysis and to incorporate by reference other documents which address cumulative effects in the Regulating Works Project Area.

Comment 30: *The National Wildlife Federation urges the Corps to expand its climate change assessment and reassess the climate change conclusions in the Phase V EA...*

The National Wildlife Federation urges the Corps to carefully assess and/or reassess the following materials in connection with its cumulative impact analysis:

- *The Midwest regional inputs to the National Climate Assessment.*
- *The 2013 Regional Climate Trends and Scenarios for the Midwest U.S....*

- *The 2009 U.S. Global Change Research Program report...*
- *The March 2005 study by the U.S. Geological Survey...*

Climate change may also significantly exacerbate the impacts on the many migratory species that utilize the Mississippi River, Mississippi River Flyway, and the project area, and these impacts must be analyzed...

Response: The District believes that the climate change assessment and conclusions adequately and accurately evaluate climate change impacts to the level necessary for this site-specific EA.

Comment 31: *Because the Phase V EA fails to adequately evaluate project impacts, it also fails to adequately evaluate whether compensatory mitigation is required.*

Response: The District believes that the Final EA adequately and accurately evaluates the impacts of the Mosenthein/Ivory Landing Phase 5 work area, and, therefore, that the conclusion that no compensatory mitigation is required is accurate. Coordination with Federal and state natural resource agencies during the planning and public review processes did not raise the need for compensatory mitigation for this work area.

Comment 32: *The many failings in the Phase V EA have resulted in a Clean Water Act Section 404(b)(1) Evaluation that fails to provide an accurate and supportable assessment of the impacts of the proposed project.*

Response: The District believes that the EA and 404(b)(1) provide accurate and supportable assessments of the impacts of the proposed action.

Appendix F. Agency and Tribal Government Coordination

Appendix F. Agency and Tribal Government Coordination

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STATE OF MISSOURI
Jeremiah W. (Jay) Nixon, Governor • Sara Parker Pauley, Director
DEPARTMENT OF NATURAL RESOURCES
www.dnr.mo.gov

February 11, 2015

Michael K. Trimble, Ph.D.
Chief, Curation & Archives Analysis Branch
St. Louis District, Corps of Engineers
1222 Spruce Street
St. Louis, Missouri 63103-2833

Re: Mosenthein Reach – Ivory Land Phase 5 Project: River Training Structures (COE) St. Louis County, Missouri

Dear Dr. Trimble:

Thank you for submitting information on the above referenced project for our review pursuant to Section 106 of the National Historic Preservation Act (P.L. 89-665, as amended) and the Advisory Council on Historic Preservation's regulation 36 CFR Part 800, which requires identification and evaluation of cultural resources.

We have reviewed the information provided concerning the above referenced project. Based on this review we concur with your recommendation that there will be **no historic properties affected** and, therefore, we have no objection to the initiation of project activities.

Please be advised that, should project plans change, information documenting the revisions should be submitted to this office for further review. In the event that cultural materials are encountered during project activities, all construction should be halted, and this office notified as soon as possible in order to determine the appropriate course of action.

If you have any questions, please write Judith Deel at State Historic Preservation Office, P.O. Box 176, Jefferson City, Missouri 65102 or call 573/751-7862. Please be sure to include the SHPO Log Number (**101-SL-15**) on all future correspondence or inquiries relating to this project.

Sincerely,

STATE HISTORIC PRESERVATION OFFICE

Mark A. Miles
Director and Deputy State
Historic Preservation Officer

MAM:jd

Promoting, Protecting and Enjoying our Natural Resources. Learn more at dnr.mo.gov

ILLINOIS HISTORIC Preservation AGENCY

FAX 217/524-7525

Monroe County PLEASE REFER TO: IHPA LOG #045021315
Merrimac
Mississippi River miles 161 to 162.5
COESTL
New construction, river training structures - Mosenthein Reach-Ivory Landing Phase 5

February 25, 2015

Michael K. Trimble, Ph.D., Chief
Department of the Army
St. Louis District, Corps of Engineers
Curation and Archives Analysis Branch (EC-Z)
1222 Spruce St.
St. Louis, MO 63103-2833

Dear Chief Trimble:

We have reviewed the documentation submitted for the referenced project(s) in accordance with 36 CFR Part 800.4. Based upon the information provided, no historic properties are affected. We, therefore, have no objection to the undertaking proceeding as planned.

Please retain this letter in your files as evidence of compliance with section 106 of the National Historic Preservation Act of 1966, as amended. This clearance remains in effect for two (2) years from date of issuance. It does not pertain to any discovery during construction, nor is it a clearance for purposes of the Illinois Human Skeletal Remains Protection Act (20 ILCS 3440).

If you are an applicant, please submit a copy of this letter to the state or federal agency from which you obtain any permit, license, grant, or other assistance.

Sincerely,

Rachel Leibowitz, Ph.D.
Deputy State Historic
Preservation Officer

1 Old State Capitol Plaza
Springfield IL 62701

ILLINOISHISTORY.GOV

STATE OF MISSOURI

Jeremiah W. (Jay) Nixon, Governor • Sara Parker Pauley, Director

DEPARTMENT OF NATURAL RESOURCES

www.dnr.mo.gov

MAY 5 2015

Mr. Jasen Brown
St. Louis District
U.S. Army Corps of Engineers
1222 Spruce St.
St. Louis, MO 63103-2833

RE: P-2919/2015-105/CES002839 in St. Louis County

Dear Mr. Brown:

The Missouri Department of Natural Resources' Water Protection Program (DNR) has reviewed the Public Notice for P-2919/2015-105 in which the U.S. Army Corps of Engineers (USACE) is proposing to construct three rootless dikes between River Miles 160.1 and 160.7 with lengths of approximately 330, 500 and 615 feet and four bendway weirs between River Miles 162.0 – 162.3 with lengths of 520, 645, 720 and 700 feet.

The project is needed to address repetitive channel maintenance dredging issues in the project area and utilizes bank stabilization and sediment management to maintain bank stability and ensure adequate navigation depth and width. Bank stabilization is achieved by revetments, whereas sediment management is achieved by river training structures, for example, dikes. Placement of material would be accomplished by track hoe or dragline crane. Stone would be transported to placement sites by barges. All construction would be accomplished from the river and all work would be performed below ordinary high water.

The U.S. Fish and Wildlife Service, Missouri Department of Conservation, Illinois Department of Natural Resources and multiple navigation industry groups were involved in the extensive coordination and planning of this project.

The proposed project is located in the Mississippi River between River Miles 160 and 162.5 in St. Louis County, Missouri, and Monroe County, Illinois.

This WQC is being issued under Section 401 of Public Law 95-217, The Clean Water Act of 1977 and subsequent revisions. This office certifies that the proposed project will not cause the general or numeric criteria to be exceeded nor impair beneficial uses established in the Water Quality Standards, 10 CSR 20-7.031, provided the following conditions are met:

1. Unwanted dredged material and river water extracted from only the Mississippi River may be placed back into the Mississippi River. The applicant shall not dispose of waste materials, water, or garbage below the ordinary high water mark of any other water body, in a wetland area, or at any location where the materials could be introduced into the water body or an adjacent wetland as a result of runoff, flooding, wind, or other natural forces.

2. Operations in the Mississippi River shall be conducted such that there will be no unreasonable interference with navigation by the existence or use of the activity.

3. Fuel, oil and other petroleum products, equipment, construction materials and any solid waste shall not be stored below the ordinary high water mark at any time or in the adjacent floodway beyond normal working hours. All precautions shall be taken to avoid the release of wastes or fuel to streams and other adjacent waters as a result of this operation.

4. Petroleum products spilled into any water or on the banks where the material may enter waters of the state shall be immediately cleaned up and disposed of properly. Any such spills of petroleum shall be reported as soon as possible, but no later than 24 hours after discovery to DNR's Environmental Emergency Response number at (573) 634-2436.

5. Only clean, nonpolluting fill should be used.

6. Conduct project activity at low flows and water levels to limit the amount of sediment disturbance caused by the heavy equipment. Limit the duration and extent that any heavy equipment is required to be in-stream.

Pursuant to Chapter 644.052.9, RSMo, commonly referred to as the Missouri Clean Water Law, this WQC shall be valid only upon payment of a fee of $150.00. The enclosed invoice contains the necessary information on how to submit your fee. Payment must be received within 15 business days of receipt of this WQC. Upon receipt of the fee, the applicable office of the USACE will be informed that the WQC is now in effect and final.

You may appeal to have the matter heard by the Administrative Hearing Commission (AHC). To appeal, you must file a petition with the AHC within 30 days after the date this decision was mailed or the date it was delivered, whichever date was earlier. If any such petition is sent by registered mail or certified mail, it will be deemed filed on the date it is mailed; if it is sent by any method other than registered mail or certified mail, it will be deemed filed on the date it is received by the AHC.

This WQC is part of the USACE's permit. Water Quality Standards must be met during any operations authorized. If you have any questions, please contact Mr. Mike Irwin by phone at (573) 522-1131, by e-mail at mike.irwin@dnr.mo.gov, or by mail at the Missouri Department of Natural Resources, Water Protection Program, P.O. Box 176, Jefferson City, MO 65102-0176. Thank you for working with the DNR to protect our environment.

Sincerely,

WATER PROTECTION PROGRAM

Chris Wieberg, Chief
Operating Permits Section

CW:mip

Enclosure

c: Ms. Sherry Bell, Fees Unit
Mr. Danny McClendon, U.S. Army Corps of Engineers, St. Louis District
Ms. Sandy Schoen, St. Louis Regional Office
Ms. Sarah Wright-Aholt, St. Louis Regional Office

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

1021 NORTH GRAND AVENUE EAST, P.O. BOX 19276, SPRINGFIELD, ILLINOIS 62794-9276 • (217) 782-2829
BRUCE RAUNER, GOVERNOR LISA BONNETT, DIRECTOR

217/782-3362

MAY 26 2015

St. Louis District
Corps of Engineers
Regulatory Branch
1222 Spruce Street
St. Louis, MO 63103

Re: U.S. Army Corps of Engineers (Monroe County)
Weir and Dike Construction – Mississippi River Miles 160 to 162.5
Log # C-0077-15 [CoE appl. # 2015-105]

Gentlemen:

This Agency received a request on February 23, 2015 from the U.S. Army Corps of Engineers requesting necessary comments concerning the construction of weirs along the Mississippi River miles 160 to 162.5. We offer the following comments.

Based on the information included in this submittal, it is our engineering judgment that the proposed project may be completed without causing water pollution as defined in the Illinois Environmental Protection Act, provided the project is carefully planned and supervised.

These comments are directed at the effect on water quality of the construction procedures involved in the above described project and are not an approval of any discharge resulting from the completed facility, nor an approval of the design of the facility. These comments do not supplant any permit responsibilities of the applicant toward the Agency.

This Agency hereby issues certification under Section 401 of the Clean Water Act (PL 95-217), subject to the applicant's compliance with the following conditions:

1. The applicant shall not cause:

   a. violation of applicable water quality standards of the Illinois Pollution Control Board, Title 35, Subtitle C: Water Pollution Rules and Regulations;

   b. water pollution defined and prohibited by the Illinois Environmental Protection Act; or

   c. interference with water use practices near public recreation areas or water supply intakes.

2. The applicant shall provide adequate planning and supervision during the project construction period for implementing construction methods, processes and cleanup procedures necessary to prevent water pollution and control erosion.

3. Any spoil material excavated, dredged or otherwise produced must not be returned to the waterway but must be deposited in a self-contained area in compliance with all state statutes, regulations and permit requirements with no discharge to waters of the State unless a permit has been issued by this Agency. Any backfilling must be done with clean material and placed in a manner to prevent violation of applicable water quality standards.

4. All areas affected by construction shall be mulched and seeded as soon after construction as possible. The applicant shall undertake necessary measures and procedures to reduce erosion during construction. Interim measures to prevent erosion during construction shall be taken and may include the installation of staked straw bales, sedimentation basins and temporary mulching. All construction within the waterway shall be constructed during zero or low flow conditions. The applicant shall be responsible for obtaining an NPDES Storm Water Permit prior to initiating construction if the construction activity associated with the project will result in the disturbance of 1 (one) or more acres, total land area. An NPDES Storm Water Permit may be obtained by submitting a properly completed Notice of Intent (NOI) form by certified mail to the Agency's Division of Water Pollution Control, Permit Section.

5. The applicant shall implement erosion control measures consistent with the "Illinois Urban Manual" (IEPA/USDA, NRCS; 2014).

6. The proposed work shall be constructed with adequate erosion control measures (i.e., silt fences, straw bales, etc.) to prevent transport of sediment and materials downstream.

7. The fill material used in waters of the State shall be predominantly sand or larger size material, with <20% passing a #230 U. S. sieve.

8. Asphalt, bituminous material and concrete with protruding material such as reinforcing bar or mesh shall not be 1) used for backfill, 2) placed on shorelines/streambanks, or 3) placed in waters of the State.

This certification becomes effective when the Department of the Army, Corps of Engineers, includes the above conditions # 1 through # 8 as conditions of the requested approval issued pursuant to Section 404 of PL 95-217.

This certification does not grant immunity from any enforcement action found necessary by this Agency to meet its responsibilities in prevention, abatement, and control of water pollution.

Sincerely,

Alan Keller

Alan Keller, P.E.
Manager, Permit Section
Division of Water Pollution Control

SAK:TJF:0077-15.docx

cc: ✓IEPA, Records Unit
IEPA, DWPC, FOS, Collinsville
IDNR, OWR, Springfield
USEPA, Region 5
Mr. Jasen Brown, U.S. Army Corps of Engineers, St. Louis District

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT CORPS OF ENGINEERS
1222 SPRUCE STREET
ST. LOUIS, MISSOURI 63103-2833

REPLY TO
ATTENTION OF:

February 17, 2015

Engineering and Construction Division
Curation and Archives Analysis Branch

Governor Edwina Butler-Wolfe
Absentee-Shawnee Tribe of Indians of Oklahoma
2025 South Gordon Cooper Drive
Shawnee, Oklahoma 74810-9381

COPY

Dear Governor Butler-Wolfe:

This letter addresses the construction of river training structures in one reach of the middle Mississippi River. River training structures are used to help reduce sediment deposition in the navigation channel and to limit the need for dredging. The U.S. Army Corps of Engineers, St. Louis District proposes adding, or modifying, seven (7) training structures.

The project is located along the Mississippi River in Monroe County, Illinois, and St. Louis County, Missouri (see Table1 below and attachment Figure 1). This federal action falls under Section 106 of the National Historic preservation Act (NHPA), in conjunction with the National Environmental Policy Act (NEPA) and the Clean Water Act (CWA). This project is being implemented to improve navigation, reduce dredging in the channel, and enhance wildlife habitat along the river.

Table 1. Proposed FY 14 River Training Structure

Major Reach	Localized Reach	Work	County	State
Mosethein-Ivory Landing Phase 5 (RM 195-154)	St Louis Harbor (RM161-163)	Dike 161.70L	Monroe	IL
		Dike 161.50L	Monroe	IL
		Dike 161.10L	Monroe	IL
		Weir 162.30R	St. Louis	MO
		Weir 162.20R	St. Louis	MO
		Weir 162.10R	St. Louis	MO
		Weir 162.00R	St. Louis	MO

In 1866 the Federal Government allocated funding for a 4-foot navigation channel between Minneapolis and St. Louis. In 1887 this channel was deepened to a 4.5-foot channel, and in 1907 it was once again deepened to a 6-foot channel from the confluence of the Mississippi and Missouri rivers to Minneapolis. This was achieved using a system of wing and closing dikes in conjunction with river dredging.

In 1927 Congress ordered USACE to study the feasibility of a 9-fooot channel on the Upper Mississippi. On July 3, 1930, an amended Rivers and Harbors Act was signed by President Hoover authorizing the creation of the channel. The primary mechanism implemented to achieve this goal was the lock-and-dam system built in the 1930s and 1940s. The use of river training structures such as wing dikes, however, continued to be valuable in the maintenance of an open river navigation channel. They

provide a more cost-effective solution for moving sediment thought the river system than dredging alone. While mitigating the need for environmentally disruptive dredging, newer designs also attempt to preserve and enhance the environmental components of the river through the creation of diverse wildlife habitats.

Training structures will be incorporated into the pre-existing system of structures already located along the river (see attachment Figure 2). There are numerous types of river training structures including dikes, revetments, rootless dikes, and bendway weirs. Among the types proposed in the work outlined in this letter are the following.

- Rootless dikes are wing dikes that are not connected to the shore. They redirect the river's own energy to manage sediment distribution within the river channel. The gap between the structure and the bank promotes habitat diversity.

- Bendway weirs are submerged rock structures that are positioned from the outside bankline of a river-bend and angled upstream toward the river flow. These underwater structures extend directly into the navigation channel and shift the current away from the outside bankline. This controls channel scouring and reduces riverbank erosion, resulting in wider and safer navigation channel through the bend without the need for periodic dredging.

Impacts to potentially significant historic properties are not anticipated during this work. River training structures are constructed using barges, without recourse to land access; therefore, any impact is limited to submerged cultural resources. Primary among these are historic period shipwrecks. Given the continual river flow and associated sedimentary erosion, deposition, and reworking, it is highly unlikely that any more ephemeral cultural material remains on the river bed. The Corps of Engineers has conducted a shipwreck survey during times of historic low water levels and maintains a database of known shipwrecks for the middle Mississippi. All proposed locations for river training structures are compared to the database as well as aerial imagery from low water years to insure historical shipwrecks are not adversely impacted. Should an inadvertent discovery of human remains occur, then state or federal law will be followed, and work will stop within the area of the discovery. Tribes will be notified, and any human remains will be treated with respect and dignity.

The U.S. Army Corps of Engineers, St. Louis District is requesting you review the maps and information about this project and notify our office if you have any concerns, such as a traditional cultural properties or sacred sites that are located within or near the project sites that need to be addressed. Please notify our office no later than March 27, 2015, if you have any areas of concern. If you have any questions regarding this matter, please contact Ms. Roberta L. Hayworth, Native American Coordinator at (314) 331-8833, or at roberta.l.hayworth@usace.army.mil. Thank you in advance for your timely review of this request. A copy of this letter has been furnished to Mr. Joseph Blanchard.

Sincerely,

Chris Pallan
for

Michael K. Trimble, Ph.D.
Chief, Curation and Archives
Analysis Branch

COPY

Attachments

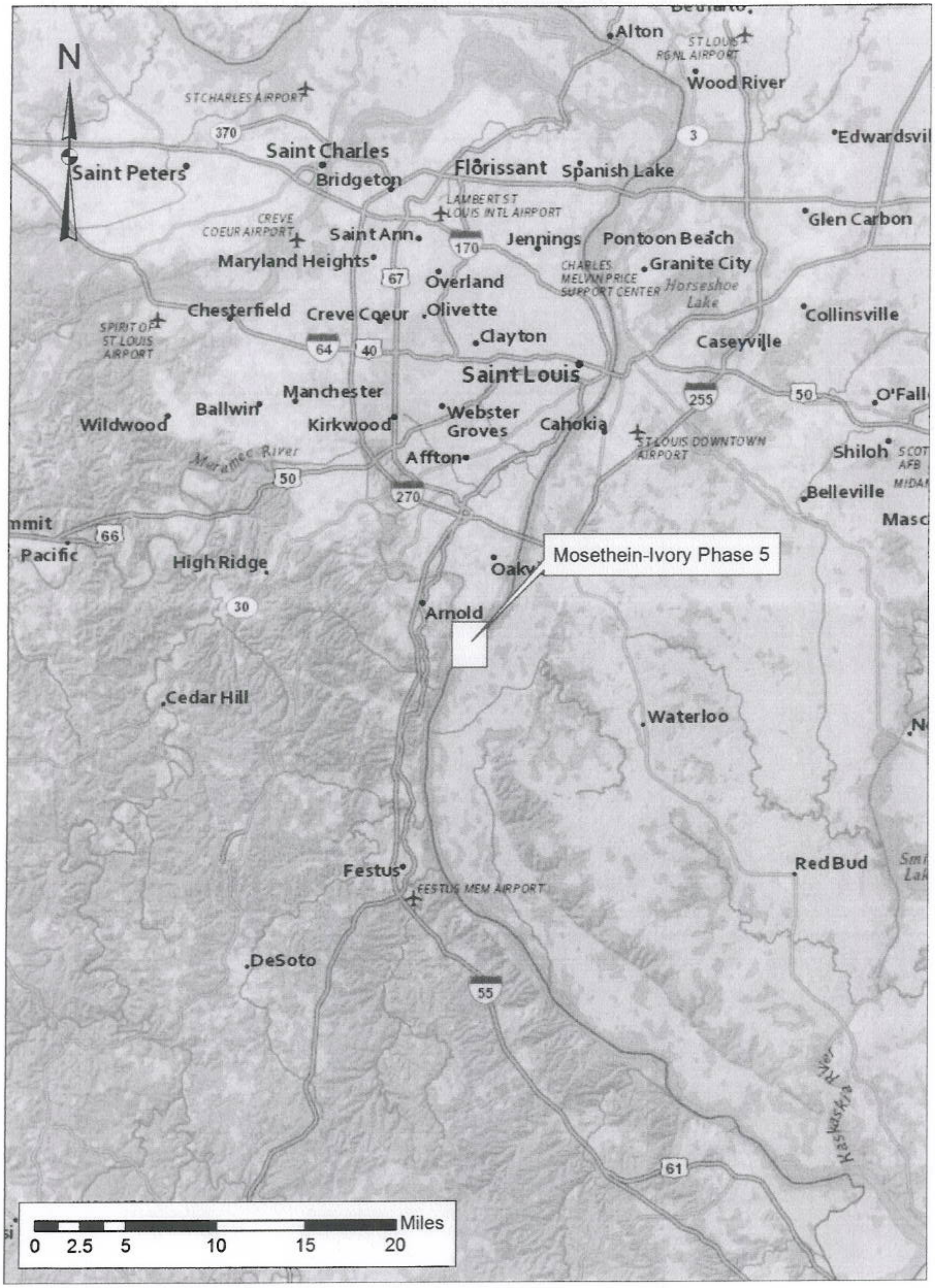

Figure 1. General project location.

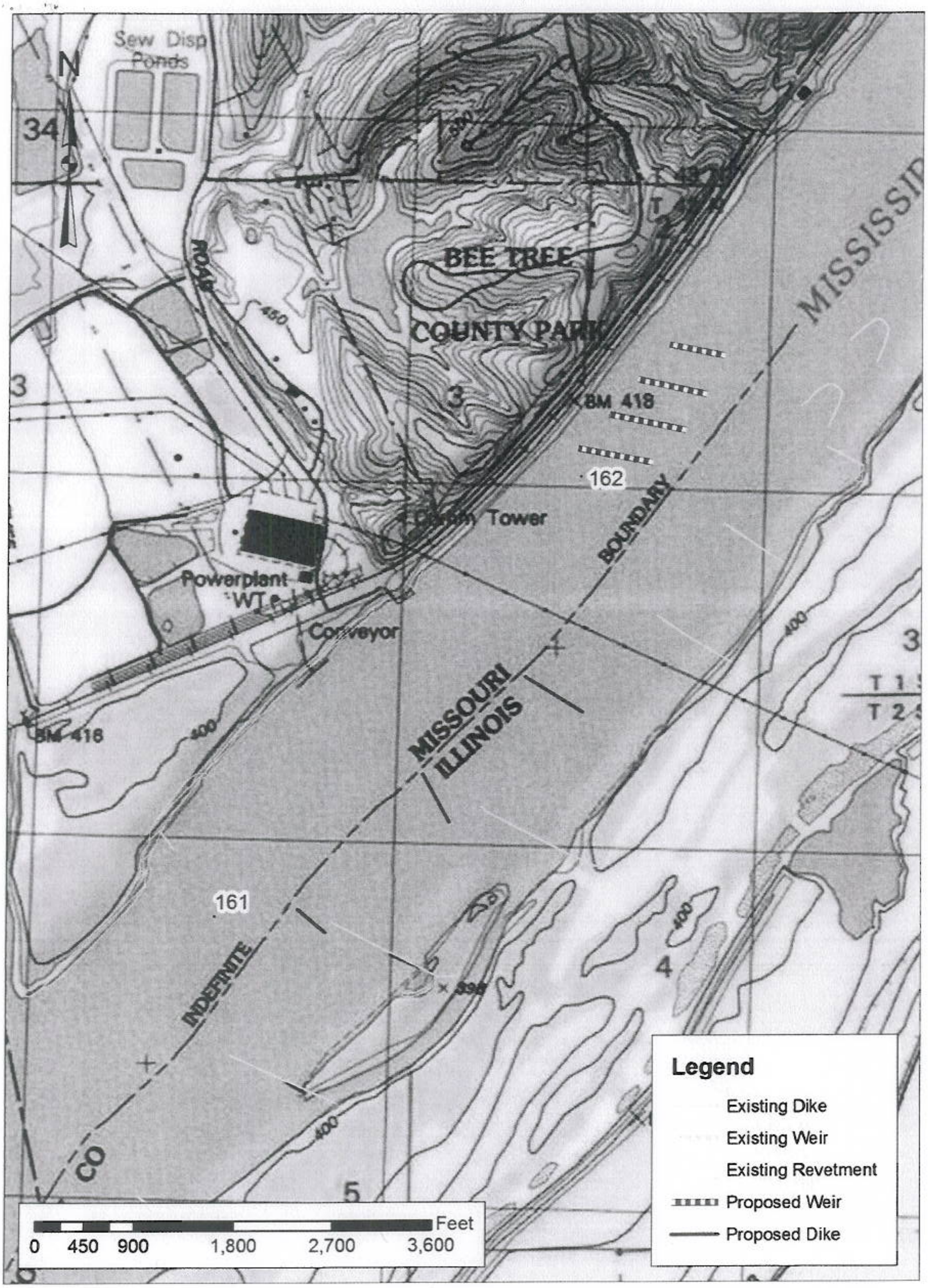

Figure 2. Location of project features.

SAME LETTER SENT:

TRIBAL CHAIRPERSONS

Governor Edwina Butler-Wolfe
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2025 S. Gordon Cooper Drive
Shawnee, Oklahoma 74810-9381

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Cherokee Nation
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Chief George Wickliffe
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Delaware Tribe of Indians
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Crandon, Wisconsin 54520

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Chairman Homer Mandoka
Nottawaseppi Huron Band of
Potawatomi of Michigan
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Fulton, Michigan 49052

Chairman John P. Warren
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Michigan and Indiana
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Dowagiac, Michigan 49047

Chairwoman Liana Onnen
Prairie Band Potawatomi Nation
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Mayetta, Kansas 66509

President Jon Greendeer
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White Cloud, Kansas 66094

Chairman Gary Pratt
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Chairman Juan Garza
Kickapoo Traditional Tribe of Texas
HC 1, Box 9700
Eagle Pass, Texas 78853

Chairman Tony Salazar
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Chairman Lester Randall
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Hiawatha, Kansas 66434

Chairwoman Judith Bender
Sac & Fox Tribe of Mississippi in Iowa
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Tama, Iowa 52339

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Miami Tribe of Oklahoma
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Miami, Oklahoma 74355

Principal Chief Geoffrey Standing Bear
The Osage Nation
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Pawhuska, Oklahoma 74056

Chief John Froman
Peoria Tribe of Indians of Oklahoma
P.O. Box 1527
118 S. Eight Tribes Trail
Miami, Oklahoma 74355

Chairman John Berrey
Quapaw Tribe of Indians
P.O. Box 765
Quapaw, Oklahoma 74363

SAME LETTER SENT:

TRIBAL REPRESENTATIVE:

Mr. Joseph Blanchard
Tribal Historic Preservation Officer
Absentee-Shawnee Tribe
2025 Gordon Cooper Drive
Shawnee, Oklahoma 74810-9381

Ms. Robin DuShane
Eastern Shawnee Tribe of Oklahoma
P.O. Box 350
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Miami, Oklahoma 74355

Dr. Richard Allen
Cherokee Nation
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Ms. Lisa Larue-Baker
Tribal Historic Preservation Officer
United Keetoowah Band of Cherokee Indians of Oklahoma
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Tahlequah, Oklahoma 74464

Ms. Nekole Allogood
Dir. Cultural & Historic Preservation Office
Delaware Nation, Oklahoma
P.O. Box 825
Anadarko, Oklahoma 73005

Dr. Bryce Obermeyer
Tribal Historic Preservation Officer
Delaware Tribe of Indians
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Dorr, Michigan 49323

Mr. Earl Meshigaud
Hannahville Indian Community
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Harris, Michigan 49845

Mr. John Rodwan
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Tribal Historic Preservation Officer
Winnebago Tribe of Nebraska
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Winnebago, Nebraska 68071

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Tribal Historic Preservation Officer
Iowa Tribe of Kansas and Nebraska
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Kickapoo Tribe of Oklahoma
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Hiawatha, Kansas 66434

Mr. Jonathan Buffalo
Sac & Fox Tribe of the Mississippi
349 Meskwaki Road
Tama, Iowa 52339

Mr. George Strack
Tribal Historic Preservation Officer
Miami Tribe
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Miami, Oklahoma 74355

Dr. Andrea Hunter
Historic Preservation Office
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Pawhuska, Oklahoma 74056

Ms. Cynthia Stacy
Peoria Tribe
118 S. Eight Tribes Trail
P.O. Box 1527
Miami, Oklahoma 74355

Mr. Everett Brandy
Tribal Historic Preservation Officer
Quapaw Tribe of Oklahoma
P.O. Box 765
Quapaw, Oklahoma 74363

Sent: Wednesday, February 18, 2015 10:14 AM

To: Hayworth, Roberta L MVS

Cc: Holly Noe

Subject:[EXTERNAL] Re: letter (UNCLASSIFIED)

Follow Up Flag: Follow up

Flag Status: Flagged

Thank you, Roberta. I have received it, read it, and am now sending you your response.

We concur with the findings and recommendations, and:

The United Keetoowah Band of Cherokee Indians in Oklahoma has reviewed your project under Section 106 of the NHPA, and at this time, have no comments or objections. However, if any human remains are inadvertently discovered, please cease all work immediately and contact us. The United Keetoowah Band of Cherokee Indians in Oklahoma reserves the right to re-enter consultation on this project at any time.

Thank you,

Lisa C. Baker

Acting THPO

United Keetoowah Band of Cherokee Indians in Oklahoma

PEORIA TRIBE OF INDIANS OF OKLAHOMA
118 S. Eight Tribes Trail (918) 540-2535 FAX (918) 540-2538
P.O. Box 1527
MIAMI, OKLAHOMA 74355

CHIEF
John P. Froman

SECOND CHIEF
Jason Dollarhide

March 4, 2015

Michael K. Trimble, Ph.D.
Chief, Curation and Archives
Analysis Branch
Department of the Army
St. Louis District Corps of Engineers
1222 Spruce Street
St. Louis, MO 63103-2833

RE: River Training Structures in the Mississippi River in Monroe County, Illinois and St. Louis County, Missouri

Dear Mr. Trimble,

The Peoria Tribe of Indians of Oklahoma is unaware of any documentation directly linking Indian Religious Sites to the proposed project location. There appear to be no objects of cultural significance or artifacts linked to our tribe located in or near the project location.

The Peoria Tribe of Indians of Oklahoma is unaware of items covered under NAGPRA (Native American Graves Protection and Repatriation Act) to be associated with the proposed project site. These items include: funerary or sacred objects; objects of cultural patrimony; or ancestral human remains.

The Peoria Tribe has no objection at this time to the proposed project. If, however, at any time items are discovered which fall under the protection of NAGPRA, the Peoria Tribe requests immediate notification and consultation. In addition state, local and tribal authorities should be advised as to the findings and construction halted until consultation with all concerned parties has occurred.

Thank you,

Cynthia Stacy

Cynthia Stacy
Special Projects Manager/NAGPRA

SEAL OF OSAGE NATION ®

RECEIVED APR 13 2015 BY:

TRIBAL HISTORIC PRESERVATION OFFICE

Date: April 9, 2015 **File: 1415-1359IL-3**

RE: USACE St. Louis District Public Notice P-2919 (2015-105) Phase V project of its Regulating Works Porject

St. Louis District, USACE
CEMVS-OD-F (Danny McClendon)
1222 Spruce Street
St. Louis, MO 63103-2833

Dear Mr. McClendon,

The Osage Nation Historic Preservation Office has evaluated your submission and concurs that the proposed USACE St. Louis District Public Notice P-2919 (2015-105) Phase V project of its Regulating Works Porject most likely will not adversely affect any sacred properties and/or properties of cultural significance to the Osage Nation. **The Osage Nation has no further concern with this project.**

In accordance with the National Historic Preservation Act, (NHPA) [54 U.S.C. § 300101 et seq.] 1966, undertakings subject to the review process are referred to in 54 U.S.C. § 302706 (a), which clarifies that historic properties may have religious and cultural significance to Indian tribes. Additionally, Section 106 of NHPA requires Federal agencies to consider the effects of their actions on historic properties (36 CFR Part 800) as does the National Environmental Policy Act (43 U.S.C. 4321 and 4331-35 and 40 CFR 1501.7(a) of 1969). **The Osage Nation concurs that the St. Louis District, USACE has fulfilled NHPA compliance by consulting with the Osage Nation Historic Preservation Office in regard to the proposed USACE St. Louis District Public Notice P-2919 (2015-105) Phase V project of its Regulating Works Porject.**

The Osage Nation has vital interests in protecting its historic and ancestral cultural resources. We do not anticipate that this project will adversely impact any cultural resources or human remains protected under the NHPA, NEPA, the Native American Graves Protection and Repatriation Act, or Osage law. **If, however, artifacts or human remains are discovered during project-related activities, we ask that activities cease immediately and the Osage Nation Historic Preservation Office be contacted.**

Should you have any questions or need any additional information please feel free to contact me at the number listed below. Thank you for consulting with the Osage Nation on this matter.

John Fox
Archaeologist

627 Grandview, Pawhuska, OK 74056, (918) 287-5328, Fax (918) 287-5376

From: Corey Smith [CSmith@delawarenation.com]
Sent: Friday, May 15, 2015 10:37 AM
To: Hayworth, Roberta L MVS
Cc: Nekole Alligood
Subject: [EXTERNAL] Construction of River Training Structures in one reach of the
middle Mississippi River

Description: Description: Large Embossed Turtle with TM.jpg

Delaware Nation

Ms. Hayworth,

Thank you for consulting with the Delaware Nation. We appreciate your willingness to conduct proper consultation with our nation. We received your letter regarding the Construction of River Training Structures in one reach of the middle Mississippi River. However, should this project inadvertently uncover an archaeological site or object(s), we request that you halt all construction and ground disturbance activities and immediately contact the appropriate state agencies, as well as our office (within 24 hours). However, this project does not lie within the Delaware Nation area of interest. Therefore, we will not be a consulting party.

Thank You,

Corey Smith
Assistant Director
Delaware Nation Cultural Preservation
P.O. Box 825
Anadarko, OK 73005

Phone: (405) 247-2448 Ext. 1405

Fax: (405) 247-8905

United States Department of the Interior

U.S. FISH AND WILDLIFE SERVICE
Marion Illinois Sub-Office (ES)
8588 Route 148
Marion, Illinois 62959
(618) 997-3344

December 4, 2014

Colonel Anthony P. Mitchell
U.S. Army Corps of Engineers
St. Louis District
1222 Spruce Street
St. Louis, Missouri 63103-2833

Attn: Mr. Francis Walton

Dear Colonel Mitchell:

Thank you for the opportunity to review and comment on the Revised Tier II Biological Assessment (BA) addressing the Mouth of the Meramec, Mosenthein Reach – Ivory Landing Phase 5 Regulating Works Project located in Monroe County, Illinois and St Louis County, Missouri. The proposed project involves the construction of 4 bendway weirs and three dikes between Upper Mississippi River Miles 161.1 and 162.3. Alternatives considered for this project included no action and a preferred alternative described above. These comments are prepared under the authority of and in accordance with the provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.); the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq*.); and, the National Environmental Policy Act (83 Stat. 852, as amended P.L. 91-190, 42 U.S.C. 4321 et seq.).

Fish and Wildlife Resources

The purpose of constructing the proposed project is to address a repetitive channel maintenance dredging issue to ensure a dependable navigation channel. Information provided in the BA indicates that the proposed weirs and one of the dikes will focus the river's energy to move sediment out of the main navigation channel and two of the dikes will deflect flow into a secondary channel to improve habitat. While not disagreeing with this assessment, the Service is concerned that the proposed construction is likely to reduce/remove habitats that are utilized by larval and juvenile fisheries resources.

The Service is also concerned about the cumulative loss of habitat and potential impacts on fisheries resources in the Mississippi River from past, present, and reasonably foreseeable future actions utilized to maintain the navigation channel. The Service recommends that the U.S. Army Corps of Engineers (Corps) continue to utilize its authorities and programs (Biological Opinion Program, Avoid and Minimize Program, and Environmental Management Program) to restore/enhance habitats in the Mississippi River. The Service also recommends that the Corps seek a post authorization change to provide for environmental protection and enhancement under the Regulating Works Project as described in the 1976 Environmental Impact Statement (EIS). As stated in the 1976 EIS, "the overall effects of the attainment of a nine-foot-navigation channel upon the riverine ecosystem has not been beneficial" and "A significant amount of fish and wildlife habitat has been affected."

Threatened and Endangered Species

The Tier II Biological Assessment (BA) which was prepared in order to comply with the requirements of the 2000 Biological Opinion for Operation and Maintenance of the 9-Foot Navigation Channel on the Upper Mississippi River System. The 2000 Biological Opinion (BO) was prepared as a result of the programmatic consultation under Section 7 of the Endangered Species Act of 1973, as amended, which evaluated the effects of operation and maintenance of the 9-foot navigation channel on federally listed threatened and endangered species. The BA evaluated the impacts of the proposed project on the endangered gray bat (*Myotis grisescens*), endangered Illinois cave amphipod (*Gammarus acherondytes*), endangered Indiana bat (*Myotis sodalis*), endangered least tern (*Sterna antillarum*), endangered pallid sturgeon (*Scaphirynchus albus*), endangered pink mucket (*Lampsilis abrupta*), endangered running buffalo clover (*Trifolium stoloniferum*), endangered scaleshell mussel (*Leptodea leptodon*), endangered sheepnose mussel (*Plethobasus cyphyus*), endangered spectaclecase (*Cumberlandia monodonta*), threatened decurrent false aster (*Boltonia decurrens*), threatened mead's milkweed (*Asclepias meadii*), and proposed as endangered northern long-eared bat (*Mytois septentrionalis*).

Information provided in the BA indicates that no caves or forests would be impacted by the proposed action; therefore, the Corps has determined the proposed project will have no effect on the gray bat, Indiana bat, and northern long-eared bat. Suitable habitat for the decurrent false aster, Illinois cave amphipod, mead's milkweed, and running buffalo clover will not be impacted by the proposed project; therefore, the Corps has determined the proposed project will have no effect on these species. The pink mucket, scaleshell, sheepnose, and spectaclecase mussels are not known to occur in the project area; therefore, the Corps has determined the proposed project will have no effect on these species. This precludes the need for further action on this project as required under Section 7 of the Endangered Species Act of 1973, as amended for the gray bat, Indiana bat, northern long-eared bat, decurrent false aster, Illinois cave amphipod, mead's milkweed, running buffalo clover, pink mucket, scaleshell, sheepnose, and spectaclecase.

Information in the BA indicates that the proposed construction activities may result in short-term adverse effects (habitat loss) at a localized scale; therefore, the Corps has determined the proposed project is likely to adversely affect the least tern and pallid sturgeon. The Service has determined that the proposed project falls within the scope of the programmatic BO issued for Operation and Maintenance of the 9-Foot Navigation Channel on the Upper Mississippi River System (Section 1.2.4.2 River Regulatory Structures). The effects of this proposed action on the least tern and pallid sturgeon are consistent with those anticipated in the programmatic BO (Sections 4.3.1.2 and 8.3.1.2 Maintenance of the 9-Foot Channel Project); therefore, the Service concurs that the proposed project is likely to adversely affect the least tern and pallid sturgeon.

Tier II Formal Consultation

As stated above, the effects of this proposed action on the least tern and pallid sturgeon are consistent with those anticipated in the programmatic BO (Sections 4.3.1.2 and 8.3.1.2 Maintenance of the 9-Foot Channel Project). The appropriate Terms and Conditions associated with the Reasonable and Prudent Measures (RPMs) identified in the programmatic BO have been adhered to (Sections 4.5.3, 4.5.4, 8.5.3 and 8.5.4). Specifically, the Corps adhered to Term and Condition 2 and RPM 1 for the least tern by submitting the project to the Service for a 30 day review period and incorporating Service recommendations to maintain flow between sandbars and the adjacent shoreline and to reduce conversion of bare sandbar habitat to woody vegetation. Based on this information, it is the Service's biological opinion that the proposed project is not likely to jeopardize the continued existence of the least tern. The Corps adhered to Term and Condition 2 and RPM 1 for the pallid sturgeon by submitting the project to the Service for a 30 day review period and incorporating Service recommendations for aquatic habitat improvement into project construction plans. Based on this information, it is the Service's biological opinion that the proposed project is not likely to jeopardize the continued existence of the pallid sturgeon. Incidental take was considered programmatically in the BO (Section 4.5 and 8.5 Incidental Take Statement) and will be evaluated at program level. Thus no incidental take statement is included with this opinion.

This concludes formal consultation on the proposed action. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

Thank you for the opportunity to provide comment on the BA. For additional coordination, please contact me at (618) 997-3344, ext. 345.

Sincerely,

/s/ Matthew T. Mangan

Matthew T. Mangan
Fish and Wildlife Biologist

cc: IDNR (Atwood, Grider)
MDC (Sternberg)

United States Department of the Interior

U.S. FISH AND WILDLIFE SERVICE
Marion Illinois Sub-Office (ES)
8588 Route 148
Marion, Illinois 62959
(618) 997-3344

April 8, 2015

Colonel Anthony P. Mitchell
U.S. Army Corps of Engineers
St. Louis District
1222 Spruce Street
St. Louis, Missouri 63103-2833

Attn: Mr. Danny McClendon

Dear Colonel Mitchell:

Thank you for the opportunity to review and comment on the Environmental Assessment (EA), Unsigned Finding of No Significant Impact (FONSI), and Public Notice P-2853 addressing the Mouth of the Meramec, Mosenthein Reach - Ivory Landing Phase 5 Regulating Works Project located in Monroe County, Illinois and St Louis County, Missouri. The proposed project involves the construction of 4 bendway weirs and three dikes between Upper Mississippi River Miles 160.0 and 162.5. Alternatives considered for this project included no action and a preferred alternative described above. These comments are prepared under the authority of and in accordance with the provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.); the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq*.); and, the National Environmental Policy Act (83 Stat. 852, as amended P.L. 91-190, 42 U.S.C. 4321 et seq.).

Fish and Wildlife Resources

The purpose of constructing the proposed project is to address a repetitive channel maintenance dredging issue to ensure a dependable navigation channel. Information provided in the EA indicates that the proposed weirs and dikes will focus the river's energy to move sediment out of the main navigation channel and that the dikes will deflect flow into a secondary channel to improve habitat. While not disagreeing with this assessment, the Service is concerned that the proposed construction is likely to reduce/remove habitats that are utilized by larval and juvenile fisheries resources.

The Service is also concerned about the cumulative loss of habitat and potential impacts on fisheries resources in the Mississippi River from past, present, and reasonably foreseeable future actions utilized to maintain the navigation channel. The Service recommends that the U.S. Army Corps of Engineers (Corps) continue to utilize its authorities and programs (Biological Opinion Program, Avoid and Minimize Program, and Environmental Management Program) to restore/enhance habitats in the Mississippi River. The Service also recommends that the Corps seek a post authorization change to provide for environmental protection and enhancement under the Regulating Works Project as described in the 1976 Environmental Impact Statement (EIS). As stated in the 1976 EIS, "the overall effects of the attainment of a nine-foot-navigation channel upon the riverine ecosystem has not been beneficial" and "A significant amount of fish and wildlife habitat has been affected."

Threatened and Endangered Species

A Tier II Biological Assessment (BA) which was prepared in order to comply with the requirements of the 2000 Biological Opinion for Operation and Maintenance of the 9-Foot Navigation Channel on the Upper Mississippi River System. The Service provided Tier II Formal Consultation in a letter dated December 4, 2014.

Conclusion

The Service concurs with the FONSI for the proposed project. Thank you for the opportunity to provide comment on the EA, FONSI, and Public Notice. For additional coordination, please contact me at (618) 997-3344, ext. 345.

Sincerely,

/s/ Matthew T. Mangan

Matthew T. Mangan
Fish and Wildlife Biologist

cc: IDNR (Atwood, Grider)
MDC (Sternberg)

Response to February 18, 2015 United Keetoowah Band Comment Letter

Comment: *The United Keetoowah Band of Cherokee Indians in Oklahoma has reviewed your project under Section 106 of the NHPA, and at this time, have no comments or objections. However, if any human remains are inadvertently discovered, please cease all work immediately and contact us. The United Keetoowah Band of Cherokee Indians in Oklahoma reserves the right to re-enter consultation on this project at any time.*

Response: If any human remains are discovered, construction will cease and all appropriate parties will be notified as soon as possible.

Response to March 4, 2015 Peoria Tribe Comment Letter

Comment: *The Peoria Tribe has no objection at this time to the proposed project. If, however, at any time items are discovered which fall under the protection of NAGPRA, the Peoria Tribe requests immediate notification and consultation. In addition state, local and tribal authorities should be advised as to the findings and construction halted until consultation with all concerned parties has occurred.*

Response: If any human remains are discovered, construction will cease and all appropriate parties will be notified as soon as possible.

Response to April 9, 2015 Osage Nation Comment Letter

Comment: *At this time, the Osage Nation Historic Preservation Office concurs that the proposed project most likely would not adversely affect any sacred properties or any sites of cultural significance to the Osage Nation. However, in the event burial remains and/or artifacts are discovered during the development or construction process, the Osage Nation would ask for immediate notification of such findings.*

Response: If any burial remains and/or artifacts are discovered, all appropriate parties will be notified as soon as possible.

Response to May 15, 2015 Delaware Nation Comment Letter

Comment: *...should this project inadvertently uncover an archaeological site or object(s), we request that you halt all construction and ground disturbance activities and immediately contact the appropriate state agencies, as well as our office (within 24 hours) .*

Response: If any archaeological sites or objects are discovered, all appropriate parties will be notified as soon as possible.

Responses to April 8, 2015 U.S. Fish and Wildlife Service Comments

Comment: *Information provided in the EA indicates that the proposed weirs and dikes will focus the river's energy to move sediment out of the main navigation channel and that the dikes will deflect flow into a secondary channel to improve habitat. While not disagreeing with this assessment, the Service is concerned that the proposed construction is likely to reduce/remove habitats that are utilized by larval and juvenile fisheries resources. The Service is also concerned about the cumulative loss of habitat and potential impacts on fisheries resources in the Mississippi River from past, present, and reasonably foreseeable future actions utilized to maintain the navigation channel.*

The Service recommends that the U.S. Army Corps of Engineers (Corps) continue to utilize its authorities and programs (Biological Opinion Program, Avoid and Minimize Program, and Environmental Management Program) to restore/enhance habitats in the Mississippi River. The Service also recommends that the Corps seek a post authorization change to provide for environmental protection and enhancement under the Regulating Works Project as described in the 1976 Environmental Impact Statement (EIS). As stated in the 1976 EIS, "the overall effects of the attainment of a nine-foot-navigation channel upon the riverine ecosystem has not been beneficial" and "A significant amount of fish and wildlife habitat has been affected."

Response: The District will continue to use existing authorities and programs, including the Biological Opinion Program, Avoid and Minimize Program, and Environmental Management Program, as appropriate, to restore and enhance Mississippi River habitats. As part of the current process to supplement the 1976 Middle Mississippi River Regulating Works Environmental Impact Statement, the District will use the alternatives and analysis provided in the 1976 EIS, including the post authorization change, and will update and consider the information as appropriate.

Appendix G. Distribution List

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Adrian, D MVS

Amato, Joel

Amy Salveter (USFWS)

Andria, Kathy Banner Press

Barker Farris,Osage Nation

Barnes, Robert

Bax, Stacia

Bellville,Colette

Bensman, Jim

Boaz, Tracy

Boehm, Gerry

Brescia, Chris

Brown, Danny

Brown, Doyle

Bruce Morrison, Great Rivers Law

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Buan, Steve

Buffalo, Jonathan

Burlingame, Chuck

Byer, J R

Caito, J

Campbell-Allison, Jennifer

Carney, Doug

Cecil Ceorst

Chicago Commods

Chief John Red

City of Portage des Sioux

Clare Mannion

Clements, Mark

Coder, Justin S
Congressman Clay
Congressman Sam Graves
Corker, Ashley
Cruse, Lester
Darst, E B
Deel, Judith
Deutsch, Charles W (Charlie) MVS
Dewey, Dave
Diedrichsen, Mike IDNR, OWR
Senator Blunt
Docks
Dougherty, Mark
Ebey, Mike
Elizabeth Hubertz
Elmestad, Gary
Engle, Lance MVS
Fabrizio, Christi
Favilla, Christy
Fay Houghton
Foster, Bill
Fung, Jenny Missouri Coalition
G, Jeff
Genz, Greg
Glenn, S
Goodwin, Bill
Gordon, David MVS
Greer, Courtney
Grider, Nathan
Gross, Andrea
Hammond, Cheryl
Hanke Terminals
Hanneman, M
Hansens Harbor
Harding, Scott
Held, Eric
Henleben, Ed
Hilburn, Craig
HMT Bell South
Hogan-Smith, Shelly
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JBS Chief
Jefferson Port Authority

Jeffries, June M MVS

Jeremy Pivor

Joeana Middleton,

Sen. McCaskill

Johnson, Erick

Johnson, Frank

Joseph Standing Bear Schranz

Kenneth Miller

Knowles, Kim

Lamm, Dawn MVS

Lange, James

Lauer, Steve

Leary, Alan

Lee, Richard J

Leipus, Ed

Leiser, Ken

Lipeles, Maxie

Louis Marine

Manders, Jon

Matthew Mangan

Mauer, Paul

Mccollum, Harold R (Raymond)

MDNR Land Rec

MDNR

Melgin, Wendy

Missouri Corn Growers Association

Muench, Lynn

Muir, T

Nelson, Lee

Novak, Ron

O'Carroll, J

Patrick Baldera, Chain of Rocks WTP

Paurus, Tim

Pehler, Kent

Peter Goode

Phillip, C

Pondrom, Gary

Popplewell, Mickey

Porter, Jason

Reitz, Paul

Rickert, Ron

Roark, Bev

Rodenberg, V

Rose Schulte

Rowe, Kelly

S, Tom

Salty, TRJ

Sauer, Randy

Schieffer, Ed

SEMO

Senator Blunt Office

Shoulberg, J

Slay, Glen

Smith, David

Southern Illinois Transfer

Spoth, Robert

Stahlman, Bill

Staten, Shane

Sternburg, Janet

Stout, Robert

Strauser, Deanne M

Teah, Philip

Todd, Brian

Tow Inc

Tyson, J

Urban, David

US Congressman Enyart

USEPA Region 7

Vest, John C MVS

Weber, Angie

Welge, Owen L

Werner, Paul

Wilmsmeyer, Dennis

Wkn, Dave

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Zupan, T

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Fay Houghton
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