Holiday Inn and Conference Center
Rock Island, Illinois

Upper Mississippi River Restoration Program Coordinating Committee

Quarterly Meeting

February 8, 2017

Agenda
with
Background
and
Supporting Materials

UPPER MISSISSIPPI RIVER RESTORATION PROGRAM
COORDINATING COMMITTEE

February 7-8, 2017

AGENDA

Tuesday, February 7 Partner Quarterly Pre-Meetings

3:45 – 5:15 p.m.	**Corps of Engineers**
3:45 – 5:15 p.m.	**Department of the Interior**
3:45 – 5:15 p.m.	**States**

Wednesday, February 8 UMRR Coordinating Committee Quarterly Meeting

Time	Attachment	Topic	Presenter
8:00 a.m.		**Welcome and Introductions**	***Don Balch**, USACE*
8:05	**A1-16**	**Approval of Minutes of November 16, 2016 Meeting**	
8:10		**Regional Management and Partnership Collaboration**	***Marv Hubbell**, USACE*
		▪ FY 2017 Fiscal Update and Scope of Work	
		▪ FY 2018 Budget Update/Appropriations Status	
	B1-9	▪ 2016 UMRR Report to Congress Status Update	
	B10	▪ UMRR External Communications Strategy	***Angie Freyermuth**, USACE*
		▪ Public Outreach and Activities	***All***
9:00		**UMRR Showcase Presentations**	
		▪ Keithsburg HREP	***Karla Sparks**, USACE*
		▪ Simulating SAV Occurrence at the HREP Scale	***Yao Yin**, USGS*
9:40		**Long Term Resource Monitoring and Science**	
	C1-10	▪ LTRM Highlights	***Jeff Houser**, USGS*
		▪ USACE LTRM Update	***Karen Hagerty**, USACE*
	C11-30	▪ FY 2017 Science Proposals	***LTRM Management Team***
		▪ A-Team Report	***Shawn Giblin**, WI DNR*
	C31-32	– Draft Fish Indicators for Consideration of Endorsement	
10:30		**Break**	
10:45		**Habitat Restoration**	
		▪ District Reports	***District HREP Managers***
	D1-36	▪ Ecosystem Resilience	***Jeff Houser**, USGS*
		▪ Habitat Needs Assessment II	***Nate De Jager**, USGS* ***Sara Schmuecker**, USFWS* ***Tim Eagan**, USACE*
11:50		**Other Business**	
	E1	▪ Future Meeting Schedule	
12:00 noon		**Adjourn**	

[See Attachment E for frequently used acronyms,
UMRR authorization (as amended), and UMRR (EMP) operating approach.]

ATTACHMENT A

Minutes

- **November 16, 2016 UMRR Coordinating Committee Quarterly Meeting** *(A-1 to A-14)*

- **November 3, 2016 UMRR Coordinating Committee Conference Call re LTRM Research Proposal** *(A-15 to A-16)*

DRAFT
Minutes of the
Upper Mississippi River Restoration Program
Coordinating Committee

November 16, 2016
Quarterly Meeting

InterContinental St. Paul Riverfront
St. Paul, Minnesota

Sabrina Chandler of the U.S. Fish and Wildlife Service called the meeting to order at 8:03 a.m. on November 16, 2016. Other UMRR Coordinating Committee representatives present were Don Balch (USACE), Mark Gaikowski (USGS), Dan Stephenson (IL DNR), Randy Schultz (IA DNR), Kevin Stauffer (MN DNR), Janet Sternburg (MO DoC), Jim Fischer (WI DNR), and Kathy Kowal (USEPA) via phone on behalf of Ken Westlake. A complete list of attendees follows these minutes.

Minutes of the August 9, 2016 Quarterly Meeting

Jim Fischer moved and Kevin Stauffer seconded a motion to approve the draft minutes of the August 9, 2016 UMRR Coordinating Committee quarterly meeting as well as the joint meeting with the Upper Mississippi River Basin Association's Board as written. The motion carried unanimously.

Regional Management and Partnership Collaboration

FY 2016 Fiscal Report

Marv Hubbell recalled that Congress appropriated $19.787 million in the FY 2016 Consolidated Appropriations Act. Later in the year, UMRR received an additional $1.387 million in the Corps work plan, bringing UMRR's total FY 2016 budget to $21.174 million. At that funding level, UMRR's FY 2016 internal allocations are as follows:

- Regional Administration and Programmatic Efforts — $891,000
- Regional Science and Monitoring — $6,567,000
  - Long term resource monitoring — $4,500,000
  - Regional science in support of restoration — $963,000
  - Regional science staff support — $129,000
  - Habitat project evaluations — $975,000
- Habitat Restoration — $13,716,000
  - Regional project sequencing — $250,000
  - MVP — $3,631,000
  - MVR — $6,318,000
  - MVS — $3,515,000

FY 2017 Appropriations Status

Hubbell reported that, on September 29, 2016, Congress enacted a continuing resolution authority (CRA) for FY 2017 that expires on December 9, 2016. District staff are directed to spend at the

CRA-level, which is $21.174 million. At this funding scenario, UMRR's FY 2017 internal allocations are as follows:

- Regional Administration and Programmatic Efforts — $761,000
- Regional Science and Monitoring — $6,714,000
  - Long term resource monitoring — $4,610,000
  - Regional science in support of restoration — $1,000,000
  - Regional science staff support — $129,000
  - Habitat project evaluations — $975,000
- Habitat Restoration — $12,525,000
  - Regional project sequencing — $150,000
  - MVP — $4,005,700
  - MVR — $4,363,600
  - MVS — $4,005,700

Hubbell noted that the Corps transferred funds among the UMRS Districts in FY 2016 in order to get critical work accomplished and to maximize the amount of funds obligated. The FY 2017 allocations to all three Districts reflect rebalancing of those internal transfers.

In response to questions from Kirsten Mickelsen and Janet Sternburg, Hubbell confirmed that the funding allocated to HREP evaluations is consistent with past years and includes an assessment of construction techniques, site visits with sponsors, and chemical, physical, and biological responses to the project features. Sternburg expressed concern that the HREP evaluation money is included in LTRM's allocation, making the money provided to science appear larger than it is. She recalled that project evaluations have historically been accounted under the HREP category. Hubbell explained that Corps leadership has expressed concern about its funding going to other agencies. This change in accounting attempts to respond that not all funds for science and monitoring are distributed to USGS and the states.

In response to a question from Jim Fischer, Hubbell explained that HREP monitoring information is located in a few different areas. This includes spreadsheets, databases, various documents, individual project evaluation reports, and the Environmental Design Handbook. Hubbell explained that participants at the September 27-29, 2016 HREP Team Meeting concluded that the individual project evaluations are not an entirely effective approach at describing success in meeting ecological objectives. The Corps is currently in the process of revamping these reports and the way that UMRR approaches project evaluations. Fischer encouraged the Corps to centralize this information into an easily-accessible location. Hubbell agreed and recognized the need to examine the benefits of habitat projects beyond the study boundary. Mickelsen stressed the need to evaluate the cumulative impact of projects in improving ecological health and better understanding how projects recreate habitats at local scales. This will be incredibly important as the competition for funding further increases. Sabrina Chandler clarified that the existing approaches to HREP evaluations are mostly focused on determining whether the Corps and sponsor have fulfilled their respective obligations.

FY 2018 President's Budget

Hubbell reported that the Office of the Assistant Secretary for the Army for Civil Works [ASA(CW)] and the Office of Management and Budget (OMB) are currently deliberating over the Corps' FY 2018 budget. Hubbell said OMB issued April 29, 2016 guidance for the FY 2018 budget process and criteria. The guidance suggests that there will not be a formal budget request and pass-back, but instead requests that agencies describe the baseline budget and any rational for proposed changes in funding levels.

However, Hubbell noted that the Corps has been approaching the FY 2018 budget development using the previous fiscal year's process. Hubbell said he participated on a November 8, 2016 conference call with staff from the ASA(CW)'s office and OMB regarding the FY 2018 UMRR budget request.

New Budget Process Potentially Starting in FY 2019

Hubbell remarked on the unprecedented amount of scrutiny that ASA(CW)'s office and OMB placed on all Corps project and program funding requests throughout the FY 2018 budget development process. Hubbell said he believes that Division and District staff did an excellent job of justify the request for UMRR, including articulating its implementation. In addition, the Corps outlined a six-year plan for implementation, demonstrated accountability through a number of metrics, and offered explanations of UMRR's importance. Hubbell said that UMRR's low cost-per-acre restored metrics were well-received. UMRR's average cost-per-acre is $3,000, when accounting for funds spent on formulating, constructing, and monitoring projects. The average cost-per-acre is $5,238 when accounting for all funds allocated to the program over time. UMRR's average obligation rate was 94.8 percent between FYs 2011 and 2013 and 99.2 percent between FYs 2014 and 2016. Other highlighted restoration accomplishments in the past six years include completing seven projects spanning 26,610 acres, initiating construction on five habitat projects spanning 14,400 acres, completing feasibility reports for seven habitat projects, and initiating studies on 11 additional habitat projects. Science accomplishments that were highlighted in the FY 2018 budget process included Light Detection and Ranging (LiDAR), land cover/land use, bathymetric, and topobathy datasets. In addition, the value of UMRR's monitoring network was underscored as was the research and analysis achievements and capabilities, particularly for the development of landscape, health, and resilience indicators and the impacts of Asian carp. Hubbell illustrated the scheduled six-year plan as presented to Corps leadership, using the following diagram:

In the future, Hubbell said he anticipates that the Corps will place greater emphasis on accountability – i.e., achieving the planned project implementation schedule – and that flexibility is seemingly decreasing. Hubbell said the six-year projections made now will likely be used to examine budget needs in the future as well as programmatic successes. In response to a question from Janet Sternburg, Hubbell said it is unclear how this new accountability metric might affect UMRR's flexibility in execution. Hubbell said Corps programs and projects faced a very high level of scrutiny, with very detailed examination of FY 2018 budget proposals. Hubbell acknowledged that new documentation approaches and tools are needed to track and report progress.

In response to a question from Jim Fischer, Hubbell said there is not a comparable program or project to gauge UMRR's cost-per-acre average. However, many within the Corps have been impressed with that number. Mark Gaikowski observed that the investment in monitoring and science results in a greater understandings of broad spatial areas, often spanning the entire system. Therefore, the cost-per-acre number is underestimated when accounting all programmatic funds. He encouraged finding a way to integrate the geographic scope that monitoring and research involves. Hubbell agreed. He explained that District staff had very little time to respond to the inquiries and tried to do the best possible to provide accurate and understandable explanations. This year, District staff received many new questions often with only a day or two to respond. Brian Johnson explained that OMB and the ASA's office are struggling with how best to evaluate the Corps ecosystem restoration programs and projects in a similar way, even though they are not comparable. A solution has not yet evolved. However, OMB and ASA have expressed concerns with the way that UMRR reports progress.

Referring to the six-year planning chart, Hubbell noted that the feasibility phase (shown in blue) should be completed within three years. The duration for completing the construction phase is dependent on the complexity of individual habitat projects. UMRR is also working to expedite the O&M phase. The chart assumes a consistent $20 million budget, and any changes in actual allocations will affect the schedule. District staff continue to stress the importance of balancing projects in all implementation phases and in each UMR District. Hubbell said he hopes that the illustration also helps USFWS and the states, particularly for managing expectations for future participation in project implementation. Hubbell stressed the importance of USFWS' and the states' involvement for advancing habitat projects. Fischer expressed support for the six-year planning chart, noting that it illustrates UMRR's complexity. He believes that the diagram will be helpful for communicating Wisconsin's interest in continuing to participate in UMRR. Sternburg agreed with Fischer's comment, and asked that Hubbell provide an update of the six-year planning chart at each UMRR Coordinating Committee's quarterly meeting. She observed that the graphic will also be helpful for better estimating when individual projects may be completed. Hubbell added that Jeff Houser is currently developing a similar six-year schedule for UMRR's science efforts.

Hubbell said District staff are developing detailed explanations regarding UMRR's programmatic allocations to be prepared for any future questions about its spending. According to Hubbell, OMB and ASA(CW) staff have provided positive feedback to UMRR's 2015-2025 Strategic Plan as well as the ecosystem resilience and Habitat Needs Assessment II efforts.

Brian Johnson reflected on OMB's and ASA(CW)'s examination of UMRR in preparation for the FY 2018 budget. Their questions were unusually detailed and mostly focused on the habitat projects. District staff were required to answer these questions with very limited time to deliberate on responses. Johnson said District staff may receive similar questions related to long term resource monitoring, noting the scrutiny over this spending just a couple years ago. He expressed concern that Corps staff may not be as prepared to justify long term resource monitoring spending with as much detail in limited timeframes. Johnson attributed UMRR's ability to maintain its flexibility in spending due to well-documented budget explanations and accounting.

Hubbell thanked Johnson for his leadership in preparing the FY 2018 budget for MVD's ecosystem restoration programs and projects. He said Johnson is a major reason that UMRR is well-positioned to compete for funding. Hubbell said Johnson did so well that he has been asked to help develop FY 2019 budgets for all Corps ecosystem restoration programs and projects nation-wide.

Jennie Sauer said USGS has a very rigorous accounting system to track spending of long term resource monitoring funding. Sauer said detailed explanations of the budget can be provided. She said any ability for the Corps to provide lead-time to prepare answers to specific inquiries would be helpful. Johnson said these questions are fairly unpredictable and timeframes to respond have varied between a week to 24 hours. Hubbell said it will be important for the Corps, USGS, and state field stations to remain prepared to provide information about specific efforts.

In response to a question from Dru Buntin, Hubbell said he does not anticipate needing to justify previous budgets. Likely budget questions would focus on current and proposed program allocations. In response to a question from Jeff Houser, Hubbell said LTRM's scopes of work may not provide sufficient detail if the questions received are similar to ones asked about the habitat projects. Johnson observed that he and Hubbell are not intending to sound any alarms as there are no indications that these questions are in fact coming. However, it will be important to have detailed budget information readily available.

Hubbell said District staff put UMRR's budget in the context of its success as measured by total acres benefitted and the ability to affect ecological resilience and address the most pressing habitat needs. Therefore, the ecosystem resilience work and Habitat Needs Assessment II (HNA II) was a primary focus of the FY 2018 budget proposal. Hubbell said UMRR's budget justification also included the statement that UMRR is only restoring the ecosystem at a rate of less than one percent while it is degrading at an average of one to three percent. The HNA II will help to quantify rates of ecological degradation.

2016 UMRR Report to Congress

Hubbell said that District staff plan to send a final draft 2016 UMRR Report to Congress (RTC) to MVD within the next two weeks. The version reflects input from MVD and Headquarters. In late November, MVD is scheduled to transmit the report to Headquarters for which it will then officially submit the report to ASA(CW) Jo-Ellen Darcy, completing the Corps' RTC obligation. In response to a question from Sternburg, Hubbell said the fate of the RTC's transmittal to OMB and Congress is unknown. He recalled that the 2010 RTC was transmitted two years after its completion. [Subsequent to the meeting, Col. Craig Baumgartner sent the draft report to MVD on November 23, 2016. Major General Michael Wehr formally transmitted the report to Corps Headquarters on December 15, 2016.]

Hubbell expressed appreciation to partners who contributed in writing and editing the report and providing information about the program's accomplishments, particularly recognizing the contributions of Kirsten Mickelsen and Karen Hagerty. In response to a question from Sternburg, Hubbell said the report can be shared externally after it is received by ASA(CW) Darcy. Mickelsen noted that a complementary brochure is being developed to help articulate the program's value.

In response to a comment from Mickelsen, Hubbell explained that the Corps substantially modified the policy statements and recommendations as they were articulated in Chapter 5 to reflect the Corps' point of view. This has mostly involved revising the issue statement regarding the challenges with non-federal sponsors executing project partnership agreements (PPAs) and removing the solutions recommended by non-federal partners. Hubbell said District staff concluded these changes were required in order so that the report would ultimately be forwarded to Congress.

Project Partnership Agreements

Buntin said UMRBA continues to work on behalf of the states to resolve challenges for them to execute the Corps' cost-share project partnership agreements (PPAs). UMRBA is currently advocating for provisions to be included in the 2016 water resources development act (WRDA) legislation that would resolve the challenges. UMRBA sent a November 14, 2016 letter to the Senate and House leadership explaining the states perspectives on several matters related to WRDA 2016, including the Corps' non-federal sponsor agreements. In particular, the letter articulated the states' preference for including an option to cap non-federal sponsors' OMRR&R obligations to 50 years and to create a more shared approach to liability. In addition, the letter requests that the Corps credit the value of donated goods rather than just the cost of the goods. Buntin explained that WRRDA 2014 directed the Corps to evaluate improvements to its PPA agreements through the National Academy of Public Administration (NAPA). However, the Corps has cited lack of subsequent appropriations for inaction. While Congressional members have expressed concern with the federal government assuming greater responsibility for liability, the states currently have to assume the full liability and all the associated costs. Buntin acknowledged that the agreements do not align with the federal government's push for partner-based approaches to water resource projects. Congressional members asked that the Corps, states, and other non-federal sponsors propose a solution that all partners agree upon.

In response to a question from Hubbell, Buntin explained that some state constitutions and laws prevent them from indemnifying a third party including the federal government because it obligates them to costs that are undefined and unlimited. Buntin said Minnesota has never cost-shared a UMRR habitat project because of the hold and save clause. While other states have executed these agreements in the past, they have indicated their unwillingness to do so going forward. Buntin suggested an in-person meeting with representatives from the Corps, states, and nonprofit organizations to discuss these challenges and potential solutions in an open, frank setting.

Kevin Stauffer echoed Buntin's overview of the problem statement, stating that it would take a significant change in the agreements before Minnesota will serve as a cost share sponsor. Stauffer said District staff explored many avenues for advancing North and Sturgeon Lakes habitat project, but it is being postponed until a non-federal cost share sponsor emerges. Tim Schlagenhaft suggested structuring liability around the likely risks associated with structural and non-structural features in the project agreements. UMRR's North and Sturgeon Lakes project could be used as an example to provide context.

Buntin added that Minnesota is seeking to resolve the PPA challenges for all types of Corps water resource projects, not just ecosystem restoration projects. There was some discussion in the WRDA 2016 negotiations about specifying the liability changes to ecosystem restoration projects only. UMRBA will continue to work with Congressional members, the Corps, states, and nonprofit organizations to find a solution and get the matter resolved. Monique Savage and Chris Erickson explained that any change to the hold and save clause will require Congressional action. However, Corps staff can discuss proposed alternatives to present to Congress for its consideration.

Dan Stephenson asked how other states across the nation are dealing with the indemnification provision. Stauffer mentioned that Minnesota has involved third parties to assume the non-federal sponsorship responsibilities following project planning. Stephenson confirmed that Illinois is no longer able to serve as a cost-share sponsor under the existing O&M and liability obligations. Hubbell said that states have previously asserted that the benefits of implementing projects outweighed the legal requirements in the PPAs. Hubbell asserted that it appears as if that sentiment has changed.

Sabrina Chandler recalled that Corps Director of Civil Works Steve Stockton explained in a June 30, 2016 letter that Congressional action is required to modify the liability clause in the cost-share agreements and that there is no flexibility to alter the existing language. Chandler suggested that the focus be on informing Congressional members of the issues and getting the legislative change needed for non-federal partners to execute the agreements that would also be acceptable by the federal government.

Hubbell pointed out that the Corps' review of its cost-share agreements resulted in its decision to remove a provision that has required tribes to waive their sovereign immunity. Hubbell views that as a positive improvement for implementing projects on tribal lands.

In response to a comment by Erickson that the issue is commonly understood, Mickelsen explained that, in developing the 2016 WIIN Act, there was some communication between Congress and the Corps that seemed to indicate some misunderstandings of the Corps' ability to modify the liability terms. UMRBA sent a May 11, 2016 letter to Mr. Stockton seeking written clarification of who would ultimately be responsible for changing the liability requirements and what changes would be necessary. This letter was sent in response to a request from a Congressional staffer because of this misunderstanding. Buntin added that Congressional members also asked for an explanation of how much additional cost the federal government would have to assume from any additional liability. Buntin said UMRBA attempted to explain that this cost cannot be estimated because the liability is unknown and will differ widely depending on each individual project's context. He said UMRBA's planned next step is to facilitate a discussion in D.C. with leadership from the Corps and state agencies and Governors' offices as well as nonprofit organizations that are likely to cost share projects. Chandler said USFWS is happy to participate in the conversations, but cannot be the work-around solution for sponsoring projects. She advised the Corps and states to find some middle ground to propose as a solution. In response to a question from Sternburg, Mickelsen said Illinois Governors staff have worked with Representative Rodney Davis' office to request that the CRS evaluate how other federal agencies such as the Bureau of Land Reclamation handle liability in their non-federal cost share agreements.

Stauffer said Minnesota offered a fairly straightforward and simple solution to allowing the Corps to revise its cost share agreements, as follows: "Notwithstanding any other provision of law, no Federal requirement that a State indemnify the Federal government as a condition of carrying out a water resources development project shall apply if such requirement is incompatible with relevant State law." In response to a question from Chandler, Stauffer clarified that this solution would apply to all types of Corps water resource projects. Mickelsen explained that, while this approach seemingly applies only to states, the assumption is that it would allow the Corps to change its liability structure in its PPA templates so that it would also apply to nonprofit organizations.

Non-Federal Partner Outreach

Buntin emphasized the importance for non-federal sponsors to deliver a shared message to the new Administration and UMRS delegation re the importance of UMRR. Buntin said he wanted to share with partners that UMRBA plans to work with coalitions like Mississippi River Cities and Towns Initiative (MRCTI) and Interstate Council on Water Policy (ICWP) to deliver shared messages to key decision makers. In particular, this includes advocating for full funding for UMRR.

Public Outreach and Engagement Activities

Randy Schultz said the American Fisheries Society sponsored his presentation to the July 18-22, 2016 International Fisheries Section meeting in the United Kingdom where he discussed the UMRS ecosystem and the UMRR's infrastructure and accomplishments, including the 30^{th} anniversary. Schultz said participants expressed strong interest in the UMRR program.

Habitat Restoration

District Reports

St. Paul District

Tom Novak reported that MVP's highest priority construction project is Conway Lake, anticipating initiating construction next on Pool 10 Islands and McGregor Lake. Harpers Slough is ahead of schedule with the project likely being completed in FY 2018. Novak said the North and Sturgeon Lakes HREP is deferred until such time that a non-federal cost share sponsor is identified. MVP will continue to work with the Fish and Wildlife Work Group to explore alternative options for advancing the project. Novak explained that the Corps is developing evaluation reports for several constructed habitat projects. However, he offered that the evaluations do not effectively link success of the project features with the intended ecological benefits.

In response to a question from Jennie Sauer, Megan Moore explained that the Corps has said it will make modifications to Peterson Lake because it is not currently meeting its intended benefits. Moore said the Lake City Field Station will use this opportunity to do some additional sampling at no cost to evaluate the benefits from the modification. Lake City will do pre-monitoring this winter and then continue to monitor the area as the project is altered.

In response to a question from Jim Fischer, Hubbell and Chandler said that Dave Potter is leading the effort to standardize project monitoring and he recently presented on this at the Fish and Wildlife Interagency Group. Hubbell added that minimum monitoring protocols are established for forested and non-forested wetlands. In response to a question from Fischer, Hubbell explained that habitat project evaluation roles are shared among the project sponsors, Corps, and field stations. Hubbell said the larger push for greater adaptive management of projects needs to be balanced with the desired spending given other program priorities.

St. Louis District

Brian Markert said Ted Shanks is MVS's greatest construction priority and is being sponsored by Missouri DoC with USFWS involvement as some of project area is under General Plan lands. Markert showcased some of the project features and their importance for providing wildlife habitat. Markert reported that construction was recently initiated on Clarence Cannon with the first contract awarded. The project involves a series of award options to allow for flexibility depending on the appropriations process. He said the Pools 25 and 26 Islands project is in the process of closing out. MVS is finalizing the project's O&M and then will conduct a site visit with USFWS. Markert said MVS is completing evaluations of Stag and Pharrs Islands HREPs. MVS is also actively planning several habitat projects and has several more in the queue. Markert reported that a meeting was held in Mid-December 2016 with Corps Headquarters and NRCS to discuss potential options for advancing the Rip Rap Landing project given conflicting land management policies between the two agencies.

In response to a question from Chandler, Don Balch said the land estate issue emerged in the context of an Omaha District project. Chandler noted that USFWS's solicitor general was involved in the Omaha District project consultation. There are projects in the Open River with similar easement questions, citing Wilkinson Island. She said USFWS would welcome being involved in these discussions.

Rock Island District

Marv Hubbell reported that planning is being initiated on Delair Division, which is moving ahead of Boston Bay as the project lacks a non-federal sponsor. Lake Odessa is now considered closed-out, with the final inspection recently complete. Hubbell announced that MVR awarded construction contracts for Pool 12 Overwintering Stage III and Huron Island Stage II, and initiated repairs to flood damages at Rice Lake. The feasibility report on Beaver Island will be completed in FY 2017 and a construction contract will be awarded in FY 2018. In response to a question from Janet Sternburg, Hubbell reported that Fox Lake was completed and turned over to USFWS.

Habitat Needs Assessment II

Tim Eagan recognized the delay in advancing the HNA II development process as planned, taking responsibility for lack of progress. Eagan explained that the Habitat Needs Assessment II (HNA II) is moving ahead with two concurrent activities: 1) a system-wide inventory of existing habitat resources and 2) a review of ecological objectives (or desired conditions) to ultimately identify habitat needs and associated restoration projects and other management actions. Eagan said the HNA II Chairs will convene a conference call with the Steering Committee soon and will consult the District-based river teams to reconsider the floodplain reach-based ecological objectives. In addition, a long-range plan will be developed for integrating the information developed during the next year with current management objectives, providing opportunities to define new or modify existing objectives, and combining the system-wide habitat inventory results with the refined management objectives to determine habitat needs.

Sara Schmuecker said she will distribute a questionnaire within the week to the four UMRS District-based river management teams asking for input on the existing set of ecological objectives in each floodplain reach, as well as ideas for any additional objectives. The resulting the suite of objectives will be used to characterize existing habitat conditions and define future habitat needs.

Jeff Houser said the HNA II steering committee includes Tom Novak and Kat McCain (USACE), Joe McMullen (USFWS), Mark Gaikowski (USGS), Kathy Kowal (USEPA), Levi Solomon (Illinois Natural History Survey), Kirk Hansen (Iowa DNR), Dan Dieterman (Minnesota DNR), and Matt Vitello (Missouri DoC). Jeff Janvrin will represent the FWWG (St. Paul District), Levi Solomon will represent the FWIC (Rock Island District), and Kat McCain will represent the RRAT (St. Louis District).

Houser said the Committee agreed to approach the HNA II with two main activities occurring simultaneously: assessing the UMRS's existing available habitat (inventory) and determining habitat needs with associated restoration projects and management approaches. Houser explained that the UMRS ecosystem goods/services and objectives will be used as an overarching framework for both identifying habitat needs and ecological resilience as well as the associated restoration needs. Packaged together in defining ecosystem goods/services and objectives are the systemic and reach-based ecological objectives, the USFWS Habitat Management Plan, the Forest Stewardship Plan, and the states' management plans. While the outcomes of the UMRS ecological resilience assessment will inform the system-wide habitat inventory, the inventory will ultimately inform the understanding of ecosystem goods/services and objectives. This essentially creates an inherent feedback loop.

Houser said the goal of the system-wide habitat inventory is to create a geodatabase of UMRS habitat maps of historic habitat conditions and various future scenarios. These maps will incorporate maps of ecologically-meaningful aquatic and floodplain habitats and models of predicted future aquatic and floodplain habitats. Houser overviewed the planned process and steps for developing the habitat maps and models, including using delineating features (e.g., side channels) from aerial photography. Ultimately, the aquatic habitat maps will provide information about the distribution of enhanced aquatic areas with associated tables and statistics of water quality attributes, aquatic vegetation, fish, mussel and waterfowl communities. The floodplain maps will indicate areas of habitat suitability associated with various vegetation types, forest compositions, and age structures among other attributes. Houser said he anticipates completing these maps by the end of FY 2017.

Houser said the HNA II Steering Committee's next steps will include reviewing proposed methods, data, and observations; seeking the river teams' input on ecosystem management objectives; and developing a long range plan for how to integrate new information into the current management objectives, defining new objectives and modifying existing ones, and combining habitat inventory results with the refined management objectives.

Chandler expressed appreciation for the thoughtful presentation, saying that it answered some of her questions regarding the lack of progress thus far and planned process for going forward. In response to a question from Jim Fischer, Houser explained that the Steering Committee will be involved in many of the next steps discussed. Eagan said that the tri-chairs will organize a conference call soon with the Steering Committee to discuss these proposed next steps. Houser added that many of these next steps were defined as recommendations in the 2000 HNA. Hubbell clarified that, unfortunately, the Steering Committee was not engaged prior to the roll out of these actions and requests for input to the river teams. Even the tri-chairs were not fully aware of that happening. But there was an opportunity to move ahead on some of the inventory work when some funding became available at the end of the FY 2016. Hubbell said that Nate De Jager pulled together a very helpful summary of the information and tools gained since 2000 that fulfills the recommendations. The next step is to ensure that the management objectives are still correct in order to define future desired conditions.

In response to a question from Jeff Ziegeweid, Houser said drawdowns may be a mechanism to realize a desired future condition. While the HNA II will focus on identifying habitat needs, UMRR employees a separate habitat project planning process where structural and non-structural measures like water level management are considered and evaluated.

Water Level Management

Kevin Stauffer overviewed the water level management presentations and discussion at UMRBA's November 15, 2016 meeting. In the end, the UMRBA Board directed staff to work with an *ad hoc* committee to plan for a regional workshop to bring partners together to discuss the challenges and opportunities for large-scale water level management (WLM). The group will develop objectives and an agenda for partner review. A primary goal will be to foster dialogue about the challenges and opportunities for larger-scale water level management.

Chandler said pool-scale WLM is working very well in the St. Louis District, generating tremendous ecological responses. For various reasons, pool management operates very differently in the St. Paul and Rock Island Districts and there are both real and perceived challenges. Chandler said she believes an interactive, in-person dialogue about challenges and opportunities would be very beneficial.

Stauffer said he and Chandler wanted to talk briefly today to share UMRBA's plans as UMRR is part of the toolbox available to implement WLM both at local- and pool-level scales. Kirsten Mickelsen said she will convene the *ad hoc* group in December and begin planning for the workshop in early 2017 in collaboration with group members. In response to a question from Sternburg, Stauffer said the workshop will discuss the relevant policies and authorities for implementing WLM on the UMRS and discuss various implementation questions, such as incorporating adaptive management principles and how to achieve built-in gains. Chandler and Ken Barr noted that an excerpt of UMRR's 2000 Implementation Guidance regarding its ability to employ large-scale WLM is provided on page C-1 of the agenda packet. The Corps also published a NESP WLM report that would be very informative for the discussion. Mickelsen and Karen Hagerty said they would make the reports available to partners. Chandler asked that individuals interested in participating as part of the *ad hoc* planning group to contact Mickelsen.

Bryan Hopkins said WLM provides a myriad of positive ecological benefits. Hopkins suggested that partners communicate the value of more routine, systemic WLM to offset dredging needs and the impact on other dynamics.

2016 UMRR HREP Team Meeting

Hubbell said the September 27-29, 2016 UMRR HREP Team Meeting was very successful in bringing together a full suite of individuals who contribute to the program's habitat projects and monitoring and science. Hubbell said he believes it showcased the incredible opportunities for integration of UMRR's restoration and science efforts. The meeting included a series of presentations on the Corps project development projects, non-federal sponsors' perspectives related to habitat projects, and the opportunities, challenges, and technical aspects of restoration involving water level management, floodplain forests, backwater lakes, and longitudinal and lateral hydraulic connectivity. In addition, presentations were given on LTRM's monitoring design and major findings as well as the ongoing resilience effort. The last day included facilitated discussion about improving HREP monitoring related to aquatic and wetland vegetation, fisheries, floodplain forest, mussels, sedimentation and geomorphology, water quality, and wildlife.

Chandler said she was not able to attend, but heard very positive feedback about the meeting. Chandler said she hopes similar meetings will be held in the future.

Long Term Resource Monitoring and Science

FY 2016 2nd Quarter Highlights

Jeff Houser reported that accomplishments of the fourth quarter of FY 2016 include:

- Publication of six manuscripts:
  - A comparison of metabolic rates in off-channel habitats of the middle Mississippi River;
  - A comparison of main and side channel physical and water quality metrics and habitat complexity in the middle Mississippi River;
  - Long-term changes in fish community structure in relation to the establishment of Asian carps in a large floodplain river;
  - Long-term decreases in phosphorous and suspended solids, but not nitrogen, in six upper Mississippi River tributaries;
  - The Mississippi River: A place for fish
  - Particle size distribution of main-channel-bed sediments along the upper Mississippi River.
- Publication of a technical report: Documenting the use of the Long Term Resource Monitoring element's fish monitoring methodologies throughout the Midwest
- The new Mussel Community Assessment Tool (MCAT) for the Upper Mississippi River
- An updated fish graphical browser [available at http://www.umesc.usgs.gov/data_library/fisheries/graphical/fish_front.html]

Assessing Recent Rates of Sedimentation

Houser reported that the UMRR Coordinating Committee voted to endorse a $36,848 proposal to research trends in backwater sedimentation rates in a special meeting held via conference call on November 3, 2016. The A-Team recommended the proposal, which will utilize FY 16 carry-over funds and will compare the current bed elevations in Pools 4, 8, and 13 with sediment transect surveys completed in 1997 and 2001. Chandler said the funding proposal is provided on pages D-15 to D-17 of the agenda packet, and a summary of the call will be made available to partners. [Note: The November 3, 2016 conference call summary is provided on pages A-15 to A-16.]

USACE Science Update

Karen Hagerty reported that Houser, on behalf of the UMRR LTRM management team, sent a November 3, 2016 email to field station team leaders, A-Team members, and UMESC LTRM staff soliciting a request for research proposals. Proposals are due on December 9, 2016 and should be sent to the LTRM management team (Marv Hubbell, Karen Hagerty, Jennie Sauer, and Houser). The total available funding for projects in FY 17 is approximately $98,150. The LTRM management team, with

Shawn Giblin as the A-Team Chair observing, will review the proposals and present its recommendations to the UMRR Coordinating Committee at its February 8, 2016 quarterly meeting.

A-Team Report

Shawn Giblin reported that A-Team's October 26, 2016 meeting included a series of presentations focused on answering questions related to how water velocity drives water quality and habitat outcomes. Giblin overviewed the major points of those presentations. The A-Team meeting also included programmatic updates and a discussion and consideration of proposed fish indicators. Giblin explained that the A-Team plans to discussed a revised version of the indicators in December and presenting the final recommendations to the UMRR Coordinating Committee at its February 8, 2016 meeting.

Science Highlight: Invasive Curly-leaf Pondweed Dynamics on the UMR

Deanne Drake presented on recent findings suggesting that LTRM's sampling underestimates the abundance invasive curly-leaf pondweed in areas where it is somewhat abundant. Drake said Shawn Giblin and John Kalas were collaborators on the research project. Drake said the invasive curly-leaf pondweed (Potamogeton crispus) is a hardy, invasive species that has a very large range. Having existed in the UMRS for over 100 years, curly-leaf pondweed is now considered naturalized.

Drake explained the plant's phenology, and that its peak production occurs in May and begins to senesce in June. This shifted phenology is unique and unlike most other aquatic plants. It also means that the late summer LTRM sampling likely underestimates the presence of curly-leaf pondweed. Drake presented evidence of this occurrence and a possible way to correct abundance scores for greater accuracy.

Drake underscored the potential significance that curly-leaf pondweed may have in terms of reducing dissolved oxygen available for fish, particularly in winter conditions. LTRM sampling shows that the abundance of curly-leaf pondweed has been Eurasian watermilfoil since 2010; however, adjusting for the seasonal phenology, curly-leaf pondweed's abundance may have been significantly greater over the long term.

Drake said the primary goals of the curly-leaf pondweed research are to 1) develop a correction for the its abundance, 2) develop a greater understanding of its seasonal biomass and nitrogen-phosphorus standing stocks, and 3) describe seasonal patterns in dissolved oxygen and other water quality implications associated with its dense growth. Drake explained the research methods, saying that 30 sites were surveyed using LTRM sampling methods for aquatic vegetation and water quality in May, July, and October 2016. In addition, plant nutrient analyses were conducted.

Drake said the results indicate that LTRM sampling is not detecting curly-leaf pondweed in areas where it is not superabundant. However, defining a correction will require additional sampling. The best estimate at this point is that curly-leaf pondweed is underestimated by about forty percent. The current understanding of curly-leaf pondweed's biomass is poor, but with some understanding that its biomass is about one hundred times greater in early spring. In addition, its sequestration estimate in May is 1,200 kg to 70,000 kg for nitrogen and 160 to 8,300 kg for phosphorous. Drake said future research could explore the feedbacks between water clarity and aquatic vegetation in the winter.

Other Business

Thank You to Janet Sternburg

Robert Stout expressed sincere thanks to Janet Sternburg for her years of dedication and service to the UMRS ecosystem, representing Missouri's best interest and overall improving the programs and projects that work to benefit fish and wildlife. As chair of the UMRBA Board, Stout awarded Sternburg with the Association's Certificate of Appreciation. He wished her all the best in her new endeavor. Sternburg said she has greatly appreciated being part of such a larger effort, with everyone working together to improve the ecological resources. UMRR is an incredible partnership where agencies can work through challenges and find solutions that are mutually beneficial. Sternburg said she will continue to be a champion for UMRR and the UMRS ecosystem in general.

Future Meetings

The upcoming quarterly meetings are as follows:

- **February 2017 — Rock Island**
  - UMRBA quarterly meeting **—** February 7
  - **UMRR Coordinating Committee quarterly meeting — February 8**
- **May 2017 — St. Louis**
  - UMRBA quarterly meeting **—** May 23
  - **UMRR Coordinating Committee quarterly meeting — May 24**
- **August 2017 — La Crosse**
  - UMRBA quarterly meeting **—** August 8
  - **UMRR Coordinating Committee quarterly meeting — August 9**

With no further business, the meeting adjourned at 12:30 p.m.

UMRR Coordinating Committee Attendance List
November 16, 2016

UMRR Coordinating Committee Members

Don Balch	U.S. Army Corps of Engineers, MVD
Sabrina Chandler	U.S. Fish and Wildlife Service, UMR Refuges
Mark Gaikowski	U.S. Geological Survey, UMESC
Dan Stephenson	Illinois Department of Natural Resources
Randy Shultz	Iowa Department of Natural Resources
Kevin Stauffer	Minnesota Department of Natural Resources
Janet Sternburg	Missouri Department of Conservation
Jim Fischer	Wisconsin Department of Natural Resources
Marty Adkins	Natural Resources Conservation Service
Ken Westlake	U.S. Environmental Protection Agency, Region 5

Others In Attendance

Thatch Shepard	U.S. Army Corps of Engineers, MVD
Chris Erickson	U.S. Army Corps of Engineers, MVP
Shahin Khazrajafari	U.S. Army Corps of Engineers, MVP
Tom Novak	U.S. Army Corps of Engineers, MVP
Ken Barr	U.S. Army Corps of Engineers, MVR
Michael Dougherty	U.S. Army Corps of Engineers, MVR
Marvin Hubbell	U.S. Army Corps of Engineers, MVR
Karen Hagerty	U.S. Army Corps of Engineers, MVR
Scott Whitney	U.S. Army Corps of Engineers, MVR
Brian Johnson	U.S. Army Corps of Engineers, MVS
Brian Markert	U.S. Army Corps of Engineers, MVS
Tim Eagan	U.S. Army Corps of Engineers, MVS
Monique Savage	U.S. Army Corps of Engineers, MVS
Kraig McPeek	U.S. Fish and Wildlife Service, RIFO
Sara Schmuecker	U.S. Fish and Wildlife Service, RIFO
Justin Sexton	U.S. Fish and Wildlife Service
Jeff Houser	U.S. Geological Survey, UMESC
Jennie Sauer	U.S. Geological Survey, UMESC
Deanne Drake	U.S. Geological Survey, UMESC
Jeff Ziegeweid	U.S. Geological Survey, Minnesota Water Science Center
Megan Moore	Minnesota Department of Natural Resources
Matt Vitello	Missouri Department of Conservation
Robert Stout	Missouri Department of Natural Resources
Bryan Hopkins	Missouri Department of Natural Resources
John Petty	Wisconsin Department of Agriculture, Trade and Consumer Protection
Shawn Giblin	Wisconsin Department of Natural Resources [On the phone]
Tim Schlagenhaft	Audubon, Minnesota
Brad Walker	Missouri Coalition for the Environment
Don Powell	SEH Inc.
Gretchen Benjamin	The Nature Conservancy
Dru Buntin	Upper Mississippi River Basin Association
Dave Hokanson	Upper Mississippi River Basin Association
Kirsten Mickelsen	Upper Mississippi River Basin Association

Upper Mississippi River Restoration Coordinating Committee
Conference Call re LTRM Research Proposal
DRAFT Minutes

November 3, 2016

UMRR Coordinating Committee Members

Sabrina Chandler	U.S. Fish and Wildlife Service
Mark Gaikowski	U.S. Geological Survey
Randy Shultz	Iowa Department of Natural Resources
Janet Sternburg	Missouri Department of Conservation
Matt Vitello	Missouri Department of Conservation
Jim Fischer	Wisconsin Department of Natural Resources
Marty Adkins	U.S. Department of Agriculture, NRCS

Other Participants

Marv Hubbell	U.S. Army Corps of Engineers
Karen Hagerty	U.S. Army Corps of Engineers
Jeff Houser	U.S. Geological Survey
Jim Rogala	U.S. Geological Survey
Dru Buntin	Upper Mississippi River Basin Association
Kirsten Mickelsen	Upper Mississippi River Basin Association

Sabrina Chandler called the meeting to order at 10:00 a.m. on November 3, 2016.

Chandler explained that the UMRR LTRM management team has requested this conference call to seek the UMRR Coordinating Committee's approval of a recommendation to fund research regarding trends in backwater sedimentation. The proposal would utilize $36,848 in FY 2016 carry-over funds. Chandler said background material was provided to the UMRR Coordinating Committee via an October 28, 2016 email from Kirsten Mickelsen.

Jeff Houser explained that the research would compare the current bed elevations in Pools 4, 8, and 13 with sediment transect surveys completed in 1997 to 2001. The study would be implemented collaboratively, with U.S. Geological Survey receiving $1,555, the Lake City Field Station receiving $18,155, the La Crosse Field Station receiving $17,137, and the Bellevue Field Station using existing funding. In order for the findings to be available for the Habitat Needs Assessment II, the study would need to move forward this winter and initial sampling to occur in the two-week period between November 7 and 18. Houser said he has consulted with all six field stations about funding this proposal and identifying any other research needs. La Grange Field Station has expressed interest in doing a similar research study in the near future.

Houser said this proposal is taking advantage of an opportunity to utilize carry-over funds. However, there is clearly a need to be better prepared for opportunities going forward. Karen Hagerty said the A-Team discussed the proposal at its October 26, 2016 meeting, agreeing to recommend to the UMRR Coordinating Committee that this proposal be funded.

Jim Fischer expressed support for funding the research proposal, noting that sedimentation is consistently identified as a major degrading stressor in virtually all UMRS ecosystem-related discussions. Fischer stressed that a contemporary assessment of rates is needed to make informed management decisions. Sternburg said she supports funding for the proposal. Observing that the proposal only evaluates sedimentation rates in the upper three study reaches, Sternburg asked if there are plans to address the same information needs in the southern three pools. Sternburg said she appreciated Houser's comments that future planning is needed. Houser said he appreciates Sternburg's concerns and that a broader distribution of research throughout the UMRS is needed. Sternburg said the 2015-2025 UMRR Strategic Plan should be used as a guide for prioritizing research needs. Houser agreed and said the LTRM management team anticipates developing research frameworks and criteria for evaluating research proposals.

Chandler reported that USGS has worked with Steve Winter to issue a special use permit. The sampling effort will not affect the closed areas where waterfowl are allowed to rest and feed.

In response to a question from Sternburg, Houser and Hagerty said that a little under $100,000 of FY 2016 carry-over remains.

In response to a question from Chandler, Fischer moved and Sternburg seconded a motion to approve $36,848 in FY 2016 carry-over funds to implement the backwater sedimentation rate study proposal for Pools 4, 8, and 13. Mickelsen reported that Kevin Stauffer and Dan Stephenson said they supported the proposal via email before the call. The motion was approved anonymously by Committee members.

The meeting adjourned at 10:25 a.m.

ATTACHMENT B

UMRR Regional Management

- **Draft 2016 UMRR Report to Congress**
  - **Full Draft Report and Brochure Available Online at** http://umrba.org//rtc2016draft.htm
  - **July 5, 2017 Draft Chapter 5** *(B-1 to B-3)*
  - **USACE HQ Office of Counsel Revisions (1/19/2017)** *(B-4 to B-5)*
  - **Brochure (Final)** *(B-6 to B-9)*

- **Excerpt of the 2015-2025 UMRR Strategic Plan (1/27/2015)** *(B-10)*

[Dated July 7, 2016, this version incorporates a few minor editorial revisions to the May 16, 2016 draft Report to Congress.]

Chapter 5
Policy Recommendations

Overview

The UMRR's reports to Congress have proven to be useful opportunities for USACE and program partners to articulate challenges and potential influences to program implementation and to recommend solutions to address them. The challenges and potential influences discussed in this chapter are beyond the partnership's ability to resolve internally at the District or Division levels and merit attention by Congress and the Administration.

Project Partnership Agreements

The UMRR has enormous potential to continue implementing habitat projects throughout the Upper Mississippi River System that will improve the ecosystem's health and resilience. The program's federal and non-federal project sponsors gain significant ecological and economic benefits from these habitat projects and are committed to continue advancing future habitat projects. However, UMRR's candidate non-federal project sponsors have concluded that the Corps' newly updated project partnership agreements (PPAs), which stipulate both parties' obligations, are too legally burdensome to execute. This could create unintended limitations on UMRR's restoration capabilities, especially as the program is set to embark on a collaborative process to identify the next generation of habitat projects. These PPA legal challenges are also limiting other Corps programs and projects and are beyond UMRR's scope to resolve. While UMRR's non-federal partners remain committed to advancing the program's habitat projects, they require that the issues as described first be addressed.

In the context of UMRR, Corps District leadership has worked with the program's non-federal sponsors in an effort to describe the PPA legal issues and identify potential solutions. According to UMRR's non-federal partners, there are two primary areas of concern. One is the indemnification provision that makes non-federal sponsors fully liable for damages resulting from the planning, design, construction, operation, and maintenance of the project, including costs for any damages that are not the result of the non-federal sponsor. The UMRR state resource management agencies assert that the requirement for non-federal sponsors to fully indemnify the Corps for all damages expect those of negligence conflicts with their respective constitutions because it requires a promise of an indeterminate amount of money for an indeterminate reason at an undetermined time in the future. The second issue is that the PPAs no longer include a time limit or cost ceiling related to the non-federal sponsors' requirement to maintain the project, essentially requiring that OMRR&R is done in perpetuity. Previously, UMRR's non-federal sponsors were required to provide OMRR&R for the life of the project, which was typically stipulated to be 50 years. In addition, the OMRR&R requirements cannot be provided to the non-federal sponsor until the PPA is signed and the project is completed.

Per UMRR's authorizing language, habitat projects require that a non-federal sponsor provide 35 percent of construction costs including planning and design unless a habitat project is located on lands managed as a national wildlife refuge, is intended to benefit a federally-listed threatened or endangered species, or provides a national benefit — e.g., treaty species. However, as a matter of policy and priorities over successive administrations, the Corps has only approved full federal funding for projects located on national wildlife refuge lands. Section 906(e) of the 1986 Water Resources Development

Act, as amended, governs cost sharing for UMRR habitat projects. In accordance with Section 107(b) of the 1992 Water Resources Development Act, operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) is the responsibility of the entity that manages the land.

Many portions of the river in serious need of restoration are located in areas with no federal lands. Habitat projects in these areas will require a non-federal sponsor to cost-share construction and assume full responsibility for OMRR&R. The addition of nonprofit organizations as candidate cost share sponsors on habitat projects, provided in the 2007 Water Resources Development Act, could substantially increase the program's restoration opportunities, particularly in the southern river reaches where there is a considerably higher proportion of private land and therefore fewer options for U.S. Fish and Wildlife Service and the states to sponsor projects.

The non-federal sponsors have proposed the following solutions to allow them to execute PPAs:

1. Modify the hold and save clause to a more equitable, shared approach to liability that does not extend beyond the liabilities that already exist under applicable state constitutions and laws.
2. Include language providing that unanticipated costs for project construction are subject to a) the state's future appropriations for the project or b) the nonprofit's availability of funds for the project. In addition, construct projects in phases when appropriate to limit cost overruns.
3. Provide greater specificity regarding OMRR&R costs and requirements in the PPAs, rather than providing those requirements post-construction. PPA provisions related to OMRR&R should include:
    a. A defined end-term that is based on the expected useful life of the project's construction features.
    b. Language providing that unanticipated costs are subject to a) the state's future appropriations for the project or b) the nonprofit's availability of funds for the project.
    c. Adaptive management provisions to address risk and uncertainty regarding project outcomes and the need and ability to perform OMRR&R obligations depending on whether the project features perform as intended.

In addition, UMRR's non-federal cost share sponsors have encouraged the Corps and the National Academy of Public Administration to involve all candidate non-federal sponsors in its efforts to improve the PPA template and preparation, negotiation, and approval process, per Section 1013 of the 2014 Water Resources and Reform Development Act.

UMRR-NESP Transition Plan

In establishing the UMRR in 1986, Congress created the first program in the nation to combine ecosystem restoration with scientific monitoring and research efforts on a large river system. In addition, Congress recognized its commitment to balanced management of the Upper Mississippi River by declaring it to be a nationally significant ecosystem and a nationally significant commercial navigation system. Since UMRR's inception, with strong Congressional support and a highly effective federal-state partnership, the program has built an effective and efficient restoration and long term resource monitoring infrastructure and has produced a strong record of accomplishments and success in improving the health and resilience of the Upper Mississippi River ecosystem.

Congress confirmed its commitment to sustainable management of the Upper Mississippi River as a multi-purpose river when it authorized the Navigation and Ecosystem Sustainability Program (NESP) in 2007. The NESP authority is the first increment of a long-term dual purpose program of ecological restoration and navigation improvement projects on the Upper Mississippi River. The NESP authority includes 225 ecosystem restoration projects, restoring over 100,000 acres, long term resource monitoring, and navigation improvements ranging from helper boats and mooring cells to seven new 1,200-foot locks (Locks and Dams 20, 21, 22, 24, and 25 on the Upper Mississippi River and La Grange and Peoria on the Illinois Waterway). The existence of two major ecosystem restoration authorities for the Upper Mississippi River has raised obvious questions about their interrelationship and potential futures. Congress declared again its commitment to sustainable management of the Upper Mississippi River and NESP in the Conference Committee report on the 2014 Water Resources Reform and Development Act (WRRDA), acknowledging that the river is the only system designated as a "nationally significant ecosystem and nationally significant navigation system."

Since the 2010 UMRR RTC, on May 14, 2012, USACE submitted a plan to transition UMRR to NESP in response to Congress' Joint Explanatory Statement included in the FY 2009 omnibus appropriations measure (P.L. 111-8). Through this plan, the Corps ensured its commitment to continuous implementation of ecosystem restoration and monitoring on the Upper Mississippi River by offering the following key principles for a successful transition:

1. A transition should occur only when NESP is appropriated construction funding, and until then, UMRR should continue to be funded.
2. Until Congress directs a transition, UMRR should remain fully functional in order to a) continue providing significant benefits to the Upper Mississippi River System region and the nation, b) maintain the ecosystem restoration and monitoring capabilities. This includes ensuring that the regional infrastructure of partnership, technical expertise, scientific monitoring and research, and construction capability will be in place for early success in implementing a robust ecosystem restoration component in NESP.
3. Extensive collaboration and coordination, including the use of a shared planning process for the identification and sequencing of habitat projects, will allow both UMRR and NESP to execute efficiently until the time of transition, with the expectation that transition will occur seamlessly and efficiently.
4. Scientific and monitoring efforts currently carried out under UMRR would integrate into NESP when a transition is ripe.
5. Long term resolution of inland navigation funding issues is needed prior to transition to ensure that comparable progress between the navigation and ecosystem restoration components can be maintained.

There are stakeholders that continue to advocate for both UMRR and NESP appropriations. In doing so, stakeholders stress many of the same transition principles incorporated in the Corps' 2012 Transition Plan. In particular, that 1) UMRR must remain fully functional unless and until a transition to NESP is ready and appropriately funded and 2) the Upper Mississippi River ecosystem restoration and science capabilities and infrastructure must be maintained and enhanced. A primary message is that NESP should be funded at levels well above UMRR's authorized level before a transition occurs so that NESP is an enhancement to UMRR's current implementation.

[Corps Headquarters Office of Counsel's revisions to the draft 2016 UMRR Report to Congress, dated November 18, 2016, sent to Rock Island District on January 19, 2017.]

Page XV - Recommendations (replaces current recommendations paragraphs)

The UMRR Program partners believe the program continues to carry out the vision of Congress for the 1,200 mile Upper Mississippi River System in exemplary fashion. The 2015-2025 Strategic Plan continues to guide partner organizations' collective work toward that vision. The environmental enhancements and progress made by UMRR and its partners could be undone without the continuation of this unified effort. ~~While~~The UMRR program partners recommend no adjustments to the authorization in this Report to Congress, and ~~to remain fully functional,~~ the Corps~~,~~ will continue ~~with its implementing partners, should continue~~ to work with its partners~~together~~ to address challenges to implementation. ~~associated with the project partnership agreements~~.

(Chapter 5) Policy Recommendations (under Project Partnership Agreements – replace whole page)

[Note: Track Changes are not provided because the following text would replace the entire Chapter 4.]

The UMRR continues to implement habitat projects throughout the Upper Mississippi River System that improve the ecosystem's health and resilience. The nation and the program's non-federal project sponsors gain significant ecological and economic benefits from these habitat projects and are committed to continue advancing future habitat projects. However, some of the requirements of law that stipulate the requirements of local cooperation are sometimes perceived by sponsors as too burdensome. These requirements of local cooperation are also applicable to other Corps' programs and projects. Addressing changes to these statutory requirements is beyond the scope of the UMRR Report.

UMRR's authorizing language requires that a non-federal sponsor of habitat projects provide 35 percent of construction costs, including planning and design, unless a habitat project meets one of the following provisions: 1) is located on lands managed as a national wildlife refuge, 2) is intended to benefit a federally listed threatened or endangered species, or 3) provides a national benefit – e.g., addresses species identified in a treaty. To date, the Corps has only approved full federal funding for projects located on refuge lands. In addition, as modified by Section 107(b) of the Water Resources Development Act of 1992, the authorization provides that operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) is the responsibility of the governmental entity that manages the land on which the project is located.

According to UMRR's non-federal partners, there are two primary areas of concern. One is the statutory requirement that the non-Federal sponsor must agree to hold and save the United States free from damages due to the construction or operation and maintenance of the project, except for damages due to the fault or negligence of the United States or its contractors. Some of the UMRR state partners assert that the indemnification requirement conflicts with state constitutions or statutes by committing them to agree to a potential payment of damages that is indefinite as to amount, purpose, and date. The second concern expressed by some partners is the statutory requirement for OMRR&R. Because a project partnership agreement is signed prior to completion of construction, the non-federal sponsors assert that they are assuming long term responsibility for OMRR&R of a project without having a complete understanding of that obligation.

Section 103(j)(1) of the Water Resources Development Act of 1986 requires that prior to initiation of a water resources development project, a non-Federal interest must enter into a binding agreement to agree to hold and save the United States free from damages due to the construction or operation and maintenance of the project, except for damages due to the fault or negligence of the project, and to pay 100 percent of the OMRR&R cost of the project. These statutory requirements are reflected in project partnership agreements, which are binding agreements required prior to initiation of water resources development projects. Legislative action is required to change these statutory requirements, which serve important interests. Section 1161 of the recently enacted Water Resources Development Act of 2016 provides additional direction regarding the development of feasibility reports for ecosystem restoration projects and non-Federal responsibilities for operation and maintenance of nonstructural and nonmechanical components of such projects.

Many portions of the river in serious need of restoration have no federal lands. Habitat projects in these areas will require a non-federal sponsor to cost-share construction and assume full responsibility for OMRR&R. The inclusion of nonprofit entities with the consent of the affected local government as eligible cost-share sponsors on habitat projects, as provided in the Water Resources Development Act of 2007, could substantially increase the program's restoration opportunities. This is particularly true in the southern river reaches where there is a considerably higher proportion of private land and therefore fewer options for U.S. Fish and Wildlife Service and the states to sponsor projects.

Recommendations (replace last bullet with this)

The Corps and non-federal habitat project sponsors should continue to work together to further inform ~~address~~ issues related to execution of project partnership agreements~~Project PPAs to identify solutions that are beneficially to both the nonfederal sponsor and the Corps~~.

Upper Mississippi River Restoration

A PROVEN SUCCESS: SAVING OUR ICONIC NATIONAL TREASURE

The mighty Mississippi River is a treasured part of our national heritage. The future of this iconic but endangered ecosystem depends on continued collaborative efforts through the Upper Mississippi River Restoration (UMRR) Program.

The Upper Mississippi River ecosystem is healthier and more resilient because of UMRR

UMRR has improved critical fish and wildlife habitat on 102,000 acres through 55 projects, with more than 50 percent of the Corps' reported wetland acres restored nationally between 2005 and 2015! These areas provide protection, nesting, and feeding areas for a highly diverse set of fish, birds, mussels, reptiles and amphibians, and mammals, including a number of rare and endangered species.

UMRR is a national leader and pioneer in large-river restoration, mimicking natural processes and restoring mosaics of wetlands, channels, and forests. UMRR's restoration techniques are tested and proven to address the most significant degrading influences to the ecosystem by:

- Protecting riverine wetlands and lakes from fluctuating water levels and high sedimentation.
- Recreating islands to provide refuge and food for many species of fish and wildlife.
- Restoring natural diversity of water velocities and depths to improve fish habitat.
- Restoring forest health and diversity, creating homes for turtles, deer, and birds.
- Reviving aquatic food webs of microorganisms, bugs, amphibians, mammals, fish, and birds, having far-reaching influences beyond immediate project sites that enhance the overall sustainability of ecological functions and processes.

Degrading influences persist

Despite significant successes, we are working against time in fighting ecosystem stressors.

- Many of the natural islands are gone, allowing stronger waves to further reduce habitat availability and quality.
- Levees and other structures disconnect the main channel from the river's floodplain habitat and filtering capacities.
- Sediment is filling in wetlands, lakes, and channels, and excess nutrients are depleting the water of oxygen needed for fish.
- Invasive species, such as Asian carp, outcompete native fish and wildlife for food sources and limited habitat.

A healthy Upper Mississippi River ecosystem is incredibly valuable for providing many economic and social benefits. Wetlands and forests filter pollutants, trap carbon, and absorb rains, keeping the river clean for swimming, boating, and fishing, mitigating climate change, and lessening flood impacts. The Upper Mississippi River generates $24.6 billion in the tourism and recreation industry.

Work Remains

Without the UMRR, the Upper Mississippi River ecosystem will degrade at an accelerated rate. Degrading stressors must be outpaced in order to sustain habitat abundance and diversity. This must include furthering our understanding of what is occurring in the Upper Mississippi River ecosystem and how best to address the most challenging causes of degradation. Investing in the river's ecosystem strengthens the nation's economy – habitat restoration enhances important ecological services and uses, such as improved water quality, benefiting municipalities, manufacturers, and renewable energy sources.

Key UMRR Accomplishments 2011-2016

Enhancing River Ecosystem Health and Resilience

- **UMRR increases habitat quantity, quality, and diversity through seven newly constructed habitat projects, directly benefiting 26,610 acres since 2011.** These projects restore natural water velocities and depths, improve vital sediment transport and distribution, create islands of varying elevations to restore natural floodplain features, and provide capabilities to mimic natural water level conditions. Collectively, these processes support a wide-range of fish and wildlife while improving the river's overall ecological integrity.

- **UMRR's interdisciplinary partnerships build smart projects.** Informed by leading professionals in a diverse suite of disciplines, UMRR's habitat project designs are comprehensive solutions to address complex habitat and ecosystem restoration needs, ultimately having enduring benefits to fish and wildlife. Teams include engineers, biologists, statisticians, mappers, and the public.

- **UMRR is getting it right – designing projects for optimal benefit.** Based upon research and 30 years of experience, we know that islands with the right topography restore healthy hardwood forests by keeping the trees drier, winter habitat for fish increases their abundance and body conditions, and mimicking natural water levels promotes wetland plant growth.

Innovating Restoration Solutions

- **UMRR develops critical tools** to understand complex relationships among riverine processes. These tools increase knowledge for determining the most pressing habitat needs, targeting the most promising restoration opportunities, and adding certainty to restoration success.

- **UMRR received the 2014 Chief of Engineers Environmental Award** in recognition of the innovation and designs of the Batchtown habitat project. This is one of many awards UMRR has received for effective and innovative restoration success, an accolade of its adaptive approach of incorporating learned insights into each successive project.

Fish are tracked using radio telemetry to observe their movement throughout UMRR's habitat projects.

Understanding the Complex and Dynamic River Ecosystem

- **Vegetation is key to getting it right!** Fish and wildlife are resilient when there is sufficient vegetation for refuge, food, spawning, and resting. And, vegetation – wetland plants and floodplain forests – requires a healthy ecosystem to support its establishment and growth. Loss of vegetation indicates a degraded system with less quality habitat to support fish and wildlife.

- **The northern portion of Upper Mississippi River has shifted to a healthier, more resilient ecosystem with more abundant vegetation.** Everywhere else, most of the river's fundamental characteristics have remained degraded but relatively stable since 2010.

- **Asian carp are drastically altering native fish communities where present, sedimentation is filling in important fish habitat and degrading water quality, and prolonged high water levels are devastating floodplain forests.** The Upper Mississippi River ecosystem will continue to face a myriad of degrading stressors, requiring ongoing restoration.

- **UMRR quantifies the resilience of the Upper Mississippi River ecosystem to remain healthy** – its capacity to absorb disturbances and sustain its fundamental ecological characteristics to support abundant and diverse habitat.




Strategic UMRR Actions for 2017-2022

Enhancing River Ecosystem Health and Resilience

- **Increase the quality, quantity, and diversity of habitat available for a wide range of fish and wildlife** through nine projects restoring 23,330 acres, while also improving the river's overall ecological integrity and sustainability. In addition, UMRR will plan for restoration opportunities using the best science available and experience from past projects.

Innovating Restoration Solutions

- **Develop indicators of ecosystem resilience** to identify locations where management intervention is needed to maintain a healthy, productive ecosystem.
- **Finalize the second comprehensive Habitat Needs Assessment,** incorporating vast amounts of learned information about how key drivers affect the river's ability to support fish and wildlife habitat as well as ecosystem health and resilience.
- **Select the next generation of habitat projects** using the Habitat Needs Assessment to identify the most pressing restoration needs and determine where restoration projects will have the greatest benefit to ecosystem health and resilience.
- **Pursue opportunities to leverage resources and information** with key decision-makers, the public, and key watershed programs and projects to improve the Upper Mississippi River ecosystem's health and resilience.

Understanding the Complex and Dynamic River Ecosystem

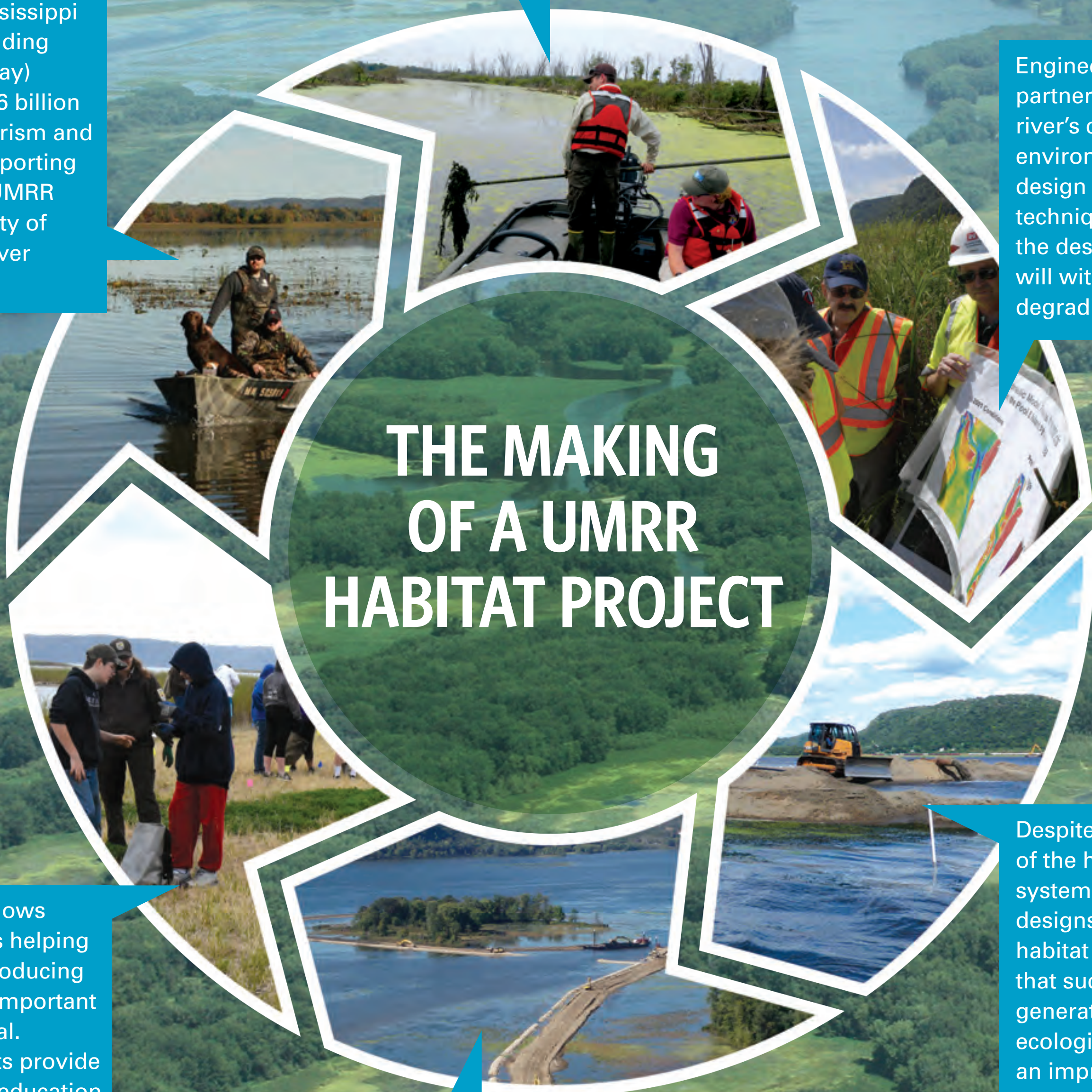
- **Increase knowledge of complex dynamics and interactions among various ecosystem characteristics and watershed drivers, and the influence of habitat projects on the Upper Mississippi River ecosystem's resilience**. This will include evaluating constructed projects and utilizing adaptive management analyses to better understand how the ecosystem responds to certain restoration techniques and approaches.
- **Assess and detect changes in the key components of the Upper Mississippi River ecosystem** through continued systemic monitoring and research, providing a broad baseline context for understanding the outcomes of UMRR's habitat projects.

Preserving the Upper Mississippi River Ecosystem

- **Without the UMRR Program, the Upper Mississippi River ecosystem will degrade at an accelerated rate and the progress that has been made to preserve this treasure for future generations will be lost.**

US Army Corps of Engineers®

THE MAKING OF A UMRR HABITAT PROJECT



Engineers, biologists, scientists, and the public examine restoration opportunities using UMRR's monitoring information to address important habitat needs.

Engineers and project partners study the river's complex environment and design restoration techniques to create the desired habitat that will withstand constant degrading forces.

Despite the complexity of the high-energy system, UMRR plans, designs, and constructs habitat projects that successfully generate the intended ecological benefits at an impressively low average cost of $3,000 per acre.

Habitat quickly becomes available post-construction! Wetland vegetation provides waterfowl habitat in just a few years. Fish populations increase from new winter habitat in less than five years with newly established populations in under 10 years.

This picture shows high-schoolers helping to plant nut-producing trees that are important for bird survival. Habitat projects provide STEM-related education opportunities for K-12 at many local schools.

The Upper Mississippi River (not including Illinois Waterway) generates $24.6 billion annually in tourism and recreation, supporting 420,000 jobs. UMRR improves quality of life for many river communities.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND, ST. PAUL, AND ST. LOUIS DISTRICTS

U.S. Army Corps of Engineers, Rock Island District | P.O. Box 2004 | Clock Tower Building | Rock Island, Illinois 61204-2004

UMRR Website: www.mvr.usace.army.mil/Missions/Environmental-Protection-and-Restoration/Upper-Mississippi-River-Restoration

Goal 3	Engage and collaborate with other organizations and individuals to help accomplish the Upper Mississippi River Restoration vision

The Upper Mississippi River is a large, complex, and dynamic ecosystem that is heavily influenced by human activity throughout its watershed. While UMRR makes significant contributions to enhancing the river ecosystem's health and resiliency, it cannot and should not attempt to meet all management needs for improving river's health. No one agency or program can solely manage this multi-use ecosystem. Rather, successful management of the UMR requires thoughtful and meaningful coordination among numerous agencies, organizations, and individuals with varying mandates and missions. This includes state and federal agencies with responsibilities related to natural resources, water quality, agriculture, transportation, and recreation; non-governmental organizations; industry representatives; academics; and the public. UMRR can aid other programs and projects that have influence on the Upper Mississippi River's condition. For example, UMRR's various datasets are readily available for broad use by Clean Water Act programs and other river managers and researchers. It will be increasingly important for UMRR to work within a watershed context and create synergies with programs and projects that will affect the Upper Mississippi River's health and resilience. In addition, interactions with other organizations and individuals that manage and conduct research nationally and internationally offer UMRR cost efficiencies and insights not otherwise available.

Objective 3.1	**Work with key organizations and individuals in the Upper Mississippi River watershed**
Strategy 1	Ensure rich collaboration with key organizations and individuals in the Upper Mississippi River watershed in advancing complementary visions, missions, and goals
Strategy 2	With key watershed programs and projects, jointly develop and communicate common messages about the restoration and knowledge needs of the Upper Mississippi River
Strategy 3	Seek knowledge from other organizations and individuals for the purposes of being aware of activities that may influence UMRR's work and enhancing programmatic efforts
Strategy 4	Directly engage relevant organizations or individuals in implementing UMRR's efforts, as appropriate
Objective 3.2	**Provide information to organizations and individuals whose actions and decisions affect the Upper Mississippi River ecosystem**
Strategy 1	Enhance the delivery and utility of UMRR's knowledge in order to increase understanding of the Upper Mississippi River's ecosystem drivers and means to achieve the UMRR vision
Strategy 2	Provide decision makers with timely, relevant, understandable, and usable knowledge about the needs and tools available to advance the UMRR's vision
Objective 3.3	**Exchange knowledge with other organizations and individuals nationally and internationally**
Strategy 1	Serve as a resource for similar programs nationally and internationally
Strategy 2	Seek knowledge from other organizations and individuals nationally and internationally to enhance UMRR's efforts in advancing its vision

ATTACHMENT C

<u>Long Term Resource Monitoring and Science</u>

UMRR Science in Support of Restoration and Management
FY2014 Scope of Work
January 2017 Status

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
Seamless Elevation Data						
2015LB9	Lidar (Tier 2) processing for Pool 1, 2, and Lockport	31-Dec-15		31-Dec-16	no cost acquisition of new LiDAR	Dieck, Hanson
2015LB10	Seamless Elevation processing for Pool 2 and 19	31-Dec-15		31-Dec-16	resolved data quality issues (Pool 19)	Dieck, Hanson
Development of Mussel Vital Rates						
2014MVR1	Brief summary report	30-Sep-15		30-Sep-15	completed, in UMESC review	Newton, Zigler, Davis
2014MVR2	Progress update	30-Sep-16		30-Sep-16		Newton, Zigler, Davis
2014MVR3	Completion report on a vital rates of native mussels at West Newton Chute, UMRS	30-Sep-17				Newton, Zigler, Davis
Effects of Nutrient Concentrations on Zoo- and Phytoplankton						
2014NC1	Counting of phytoplankton samples	13-Mar-15		2-Mar-15		Giblin, Campbell, Houser, Manier
2014NC2	Database completed and analysis completed	13-Mar-16	13-Mar-17		Working With UWL staff. Analysis will have to be conducted after academic year.	Giblin, Campbell, Houser, Manier
2014NC3	Full manuscript completed	13-Mar-18				Giblin, Campbell, Houser, Manier
Ecological Shifts Turbid to Clear States						
2014ES1	Literature review and initial analyses competed	13-Mar-15		15-Nov-14		Giblin, Ickes, Langrehr, Bartels
2014ES2	Refined analyses and draft manuscrpt prepared	13-Mar-16		4-Jan-16	reconciling journal review comments	Giblin, Ickes, Langrehr, Bartels
2014ES3	Manuscipt submitted for publication	13-Mar-17				Giblin, Ickes, Langrehr, Bartels
Asian Carps Recruitment Sources (#2)						
2014CRS1	Summary letter	31-Jan-15		16-Jan-15		Phelps, Mccain
2014CRS2	Manuscript	31-Mar-16	30-Aug-16	30-Aug-16	in review at Aquatic Invasions	Phelps, Mccain
Effects of Asian Carps on Native Piscivore Diets (#3)						
2014NPD1	Summary letter	31-Jan-15		16-Jan-15		Phelps, Mccain
2014NPD2	Manuscript	31-Mar-16	30-Oct-16	17-Nov-16	submitted to Environmental Biology of Fishes	Phelps, Mccain

UMRR Science in Support of Restoration and Management
FY2015 Scope of Work
January 2017 Status

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
Early Life History of Invasive Carps (#4)						
2014CLH1	Summary letter	31-Jan-15		16-Jan-15		Phelps, Mccain
2014CLH2	Manuscript	31-Mar-16		1-Jan-16	in press	Phelps, Mccain
Fish Indicators of Ecosystem Health						
2015FI1	Preliminary set of species identified for the different assemblages by study reach submitted to A-Team as status update and for review	30-Aug-15	10-Feb-16	16-Feb-16	Post doc hiring delay resulted in project delayed	Anderson, Casper, McCain
2015FI2	Draft recommendation for the best attainable or target for each assemblage by study reach submitted to A-Team for Review	1-Oct-15	10-Feb-16	16-Feb-16	For presentation at 2016 UMRR Science Mtg in La Crosse briefing	Anderson, Casper, McCain
2015FI3	Initial draft Project Report submitted to A-Team for review	1-Dec-15	15-Mar-16	30-Mar-16	Incorporate feedback from 2016 UMRR Science Mtg presentation into La Crosse A-team briefing	Anderson, Casper, McCain
2015FI4	Final draft Project Report submitted to A-Team for review and endorsement at JANUARY meeting	1-Mar-16	15-Dec-16	16-Dec-16	all requested changes were made	Anderson, Casper, McCain
2015FI5	Final draft Project Report submitted to UMRR CC for endorsement at FEBRUARY meeting	15-Jul-16	15-Jan-17	15-Jan-17	on schedule	Anderson, Casper, McCain
2015FI6	Final Report	1-Jun-16	28-Feb-17			Anderson, Casper, McCain
Plankton community dynamics in Lake Pepin						
2015LPP1	Phytoplankton processing; species composition, biovolume	30-Dec-15		22-Oct-15		Burdis
2015LPP2	draft manuscript: Plankton community dynamics in Lake Pepin	30-Sep-16	30-Mar-18		delayed due to field station staffing shortages and will also include data from 2015D15	Burdis
Estimating trends in UMRR fish and vegetation levels using state-space models						
2015SST1	Draft completion report: Evaluation of trend estimation methods for LTRM fish and vegetation indices	30-Sep-15	15-Dec-15	29-Jan-16	Project delayed by computing challenges.	Gray
2015SST2	Final completion report: Evaluation of trend estimation methods for LTRM fish and vegetation indices	31-Dec-15	15-Mar-16	27-Mar-16		Gray
2015SST3	Provide trend estimates for fish and vegetation web browser pages	30-Sep-16	31-Dec-16	27-Dec-16		Gray, Schlifer
Predictive Aquative Cover Type Model - Phase 2						
2015AQ1	Develop 2-D hydraulic model of upper Pool 4	30-Sep-15		30-Sep-15		Libbey (MVP H&H)
2015AQ2	Apply model to Pool 4 and resolve discrepancies	31-Dec-15	31-Mar-16	31-Mar-16		Yin, Rogala
2015AQ3	Detailed summary of work for Phases I & II	31-Dec-15	3-Jun-17		Resolving model discrepancy took longer than anticipated. Needs extension of summary deadline	Yin, Rogala, Ingvalson

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
Aquatic Vegetation Component						
2017A1	Complete data entry and QA/QC of 2016 data; 1250 observations.					
	a. Data entry completed and submission of data to USGS	30-Nov-16		30-Nov-16		Lund, Drake, Bales
	b. Data loaded on level 2 browsers	15-Dec-16		15-Dec-16		Schlifer
	c. QA/QC scripts run and data corrections sent to Field Stations	28-Dec-16		28-Dec-16		Sauer, Schlifer
	d. Field Station QA/QC with corrections to USGS	15-Jan-17				Lund, Drake, Bales
	e. Corrections made and data moved to public Web Browser	30-Jan-17				Yin, Sauer, Schlifer, Caucutt
2017A2	Web-based: Creating surface distribution maps for aquatic plant species in Pools 4, 8, and 13; 2016 data	31-Jul-17				Yin, Rogala, Schlifer
2017A3	Wisconsin DNR annual summary report 2016 that combines current year observations from LTRM with previous years' data, for the fish, aquatic vegetation, and water quality components.	30-Sep-17				Drake, Bartels, Hoff, Kalas
2017A4	Complete aquatic vegetation sampling for Pools 4, 8, and 13 (Table 1)	31-Aug-17				Yin, Lund, Drake, Bales
2017A5	Pool 4: Graphical summary and maps of aquatic vegetation current status and long-term trends.	30-Dec-16		21-Oct-16		Lund
2017A6	Pool 8: Graphical summary and maps of aquatic vegetation current status and long-term trends.	30-Dec-16		19-Sep-16		Drake, Weeks
Intended for distribution						
LTRM Technical Report: Ecological Assessment of High Quality UMRS Floodplain Forests (2007APE12; Chick, Guyon, Battaglia) (in final edits with author)						
LTRM Technical Report; Experimental and Comparative Approaches to Determine Factors Supporting or Limiting Submersed Aquatic Vegetation in the Illinois River and its Backwaters (2008APE5, Sass) (in USGS review)						
LTRM completion report: FY05-07 data--Analysis and support of aquatic vegetation sampling data in Pools 6, 9, 18, and 19 (2008APE4a; Yin) (in USGS review)						
Manuscript: Have the recent increases in aquatic vegetation in Pools 5 and 8 been the result of water level management drawdowns, HREPs, or natural fluctuations? (2009APE1a; Yin) (in USGS review)						
Manuscript: A statistical model of species occupancy using the LTRM aquatic vegetation data (2013A7; Yin) (in USGS review)						
Fisheries Component						
2017B1	Complete data entry, QA/QC of 2016 fish data; ~1,590 observations					
	a. Data entry completed and submission of data to USGS	31-Jan-17				DeLain, Bartels, Bowler, Ratcliff, Gittinger, West, Solomon, Maxson
	b. Data loaded on level 2 browsers; QA/QC scripts run and data corrections sent to Field Stations	15-Feb-17				Ickes, Schlifer
	c. Field Station QA/QC with corrections to USGS	15-Mar-17				DeLain, Bartels, Bowler, Ratcliff, Gittinger, West, Solomon, Maxson
	d. Corrections made and data moved to public Web Browser	30-Mar-17				
2017B2	Update Graphical Browser with 2016 data on Public Web Server.	31-May-17				Ickes, Sauer, and Schlifer
2017B3	Complete fisheries sampling for Pools 4, 8, 13, 26, the Open River Reach, and La Grange Pool (Table 1)	31-Oct-17				Ickes, Sauer, DeLain, Bartels, Bowler, Ratcliff, Gittinger, West, Solomon, Maxson, Schlifer
2017B4	Summary Letter: Floodplain fisheries sampling	31-Oct-17				Ickes, DeLain, Bartels, Bowler, Ratcliff, Gittinger, West, Solomon, Maxson
2017B5	IDNR Fisheries Management State Report: Fisheries Monitoring in Pool 13, Upper Mississippi River, 2016	30-Jun-17				West, Sobotka

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
2017B6	Sample collection, database increment, Summary letter on Asian carp age and growth: collection of cleithral bones	31-Jan-17				Bowler
2017B7	Sample collection, database increment, letter summary: Collection and archiving of age and growth structure for selected species in the La Grange Reach of the Illinois River	31-Jan-17				Solomon, Maxson, Casper
2017B8(D)	Database increment: Stratified random day electrofishing samples collected in Pools 9–11	30-Sep-17				Solomon, Maxson, Casper
2017B9(D)	Database increment: Stratified random day electrofishing samples collected in Pools 16–18	30-Sep-17				Bowler
2017B10	Summary Letter: Open River Chevron Dike monitoring	31-Oct-17				Bowler
2017B11	Summary Letter: Evaluating the Fish Community in a rare Backwater Habitat in the Middle Mississippi River 2017	30-Sep-17				West
Intended for distribution						
Completion report: LTRM Fisheries Component collection of six darter species from 1989–2004. (2006B13; Ridings) (in USGS review)						
LTRM technical report; Setting quantitative fish management targets for LTRM monitoring (2008APE2; Sass) (in USGS review)						
LTRM Completion report, compilation of 3 years of sampling: Fisheries (2009R1Fish; Chick et al.) (in USGS review)						
Manuscript: Determining environmental history of three sturgeon species in the Upper, Middle, and Lower Mississippi Rivers. (2013B22; Phelps) (in review Journal of Fish Biology)						
Manuscript: Age-0 sturgeon habitat associations in the free flowing portion of the Upper Mississippi River (2012B5; Tripp, Phelps, Herzog) (in review Journal of Fish Biology)						
Manuscript: Population Trends and a Distributional Record of Selected Fish Species from the Illinois River; Levi E. Solomon, Richard M. Pendleton, Robert A. Hrabik, and Andrew F. Casper Completed: Transactions of the Illinois State Academy of Science (2016) Volume 109, pp. 57-61						
LTRM Fact Sheet: Tree map tool for visualizing fish data, with example of native versus non-native fish biomass (2013B16) (in USGS review)						
Water Quality Component						
2017D1	Complete calendar year 2016 fixed-site and SRS water quality sampling	31-Dec-16		31-Dec-16		Jankowski, Burdis, Kalas, Kueter, L. Gittinger, Kellerhals, Sobotka
2017D2	Complete laboratory sample analysis of 2016 fixed site and SRS data; Laboratory data loaded to Oracle data base.	15-Mar-17				Yuan, Schlifer
2017D3	1st Quarter of laboratory sample analysis (~12,600)	30-Dec-17				Yuan, Manier, Burdis, Kalas, Kueter, L. Gittinger, Cook, Sobotka
2017D4	2nd Quarter of laboratory sample analysis (~12,600)	30-Mar-17				Yuan, Manier, Burdis, Kalas, Kueter, L. Gittinger, Kellerhals, Sobotka
2017D5	3rd Quarter of laboratory sample analysis (~12,600)	29-Jun-17				Yuan, Manier, Burdis, Kalas, Kueter, L. Gittinger, Kellerhals, Sobotka
2017D6	4th Quarter of laboratory sample analysis (~12,600)	28-Sep-17				Yuan, Manier, Burdis, Kalas, Kueter, L. Gittinger, Kellerhals, Sobotka

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
2017D7	Complete QA/QC of calendar year 2016 fixed-site and SRS data.					
	a. Data loaded on level 2 browsers; QA/QC scripts run; SAS QA/QC programs updated and sent to Field Stations with data.	30-Mar-17				Schlifer, Rogala, Jankowski
	b. Field Station QA/QC; USGS QA/QC.	15-Apr-17				Jankowski, Rogala, Burdis, Kalas, Kueter, L. Gittinger, Kellerhals, Sobotka
	c. Corrections made and data moved to public Web Browser	30-Apr-17				Rogala, Schlifer, Jankowski
2017D8	Complete FY2017 fixed site and SRS sampling for Pools 4, 8, 13, 26, Open River Reach, and La Grange Pool	30-Sep-17				Jankowski, Burdis, Kalas, Kueter, L. Gittinger, Kellerhals, Sobotka
2017D9	WEB-based annual Water Quality Component Update w/ 2016 data on Server.	30-May-17				Rogala
2017D10	Final LTRM Completion report: Evaluation of water quality data from automated sampling platforms	30-Sep-17				Soeken-Gittinger,Lubinski, Chick, Houser
2015D11	Operational Support to the UMRR LTRM Element. Serve as in-house Field Station for USGS for consultation and support on various LTRM-wide topics	30-Sep-17				Kalas, Hoff, Bartel, Drake
2015D12	Final report/manuscript: Developing continuous water quality monitoring methods in the UMR	1-Sep-17				Chick, Houser
Intended for distribution						
Completion report: Examining nitrogen and phosphorus ratios N:P in the unimpounded portion of the Upper Mississippi River (2006D9; Hrabik & Crites) (in USGS review)						
LTRM report: Main channel/side channel report for the Open River Reach. (2005D7; Hrabik) (replaced with Sobotka, M. J. and Q. E. Phelps. 2016. A Comparison of Main and Side Channel Physical and Water Quality Metrics and Habitat Complexity in the Middle Mississippi River)						
Manuscript:Contrasts between channels and backwaters in a large, floodplain river: testing our understanding of nutrient cycling, phytoplankton abundance, and suspended solids dynamics (2012D10; Houser) (Freshwater Science. 2016. 35(2):457–473. DOI: 10.1086/686171)						
Completion report, compilation of 3 years of sampling: Water Quality (2009R1WQ; Giblin, Burdis) (in USGS review)						
Manuscript: Trends in suspended solids, nitrogen, and phosphorus in select upper Mississippi River tributaries, 1991-2011 (Kreiling and Houser, 2013D14) (Environ Monit Assess. 188: 454. doi:10.1007/s10661-016-5464-3)						
Manuscript: Relationship between the temporal and spatial distribution, abundance, and composition of zooplankton taxa and hydrological and limnological variables in Lake Pepin (2013D17; Burdis) (ready for submission to Journal)						
Manuscript: Nutrients and dissolved oxygen in the UMRS: improving our understanding of winter conditions and their implications for structure and function of the river (2014D12; Houser) (in USGS review)						
Land Cover/Land Use with GIS Support						
2017LC1	Maintenance ArcGIS server	30-Sep-17				Hlavacek, Fox, Rohweder
2017LC2	Aerial Photo scanning	30-Sep-17				Ruhser
2017LC3	USNVC Database Table	30-Sep-17				Hop
2017LC4	Updates on progress for land cover products listed.	New progress reported in the quarterly activities. Percent complete updated 30 Sept 2017.				Robinson
Data Management						
2017M1	Update vegetation, fisheries, and water quality component field data entry and correction applications.	30-May-17				Schlifer
2017M2	Load 2016 component sampling data into Oracle tables and make data available on Level 2 browsers for field stations to QA/QC.	30-Jun-17				Schlifer

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
Quarterly Activities						
2017QR1	Submittal of quarterly activities	30-Jan-17				All LTRM staff
2017QR2	Submittal of quarterly activities	13-Apr-17				All LTRM staff
2017QR3	Submittal of quarterly activities	13-Jul-17				All LTRM staff
2017QR4	Submittal of quarterly activities	12-Oct-17				All LTRM staff
Equipment Inventory						
2017ER1	Property inventory and tracking	15-Nov-17				LTRM staff as needed

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
Developing and Applying Indicators of Ecosystem Resilience to the UMRS						
2017R1	Updates provided at quarterly UMRR CC meeting and A team meetings	Various				Bouska, Houser
2017R2	Submit following manuscript for publication: Bouska, K.B., J.N. Houser,	30-May-17				Bouska, Houser, De Jager
2017R3	Draft General Resilience of the UMRS manuscript to RWG for review	15-Sep-17				Bouska, Houser
Modelling and mapping current and projected future habitats of the Upper Mississippi River System (HNA-II)						
Aquatic Habitats						
2017AH1	Develop general classification for 2010 and refit 1989-- Key Pools completed	30-Jan-17				Janis Rusher
2017AH2	Develop general classification for 2010 and refit 1989-- Rest of system	30-Jul-17				Janis Rusher
2017AH3	Develop enhanced lentic areas--Add Connectivity and depth of side channels, structured MCB to aquatic areas for Key Pools	30-Jan-17				Jim Rogala
2017AH4	Develop enhanced lentic areas--Add Connectivity and depth of side channels, structured MCB to aquatic areas for rest of system	30-Aug-17				Jim Rogala
2017AH5	Develop enhanced lotic areas--Add Connectivity and depth of side channels, structured MCB to aquatic areas for Key Pools	30-Jan-17				Jason Rohweder
2017AH6	Develop enhanced lotic areas--Add Connectivity and depth of side channels, structured MCB to aquatic areas for rest of system	30-Aug-17				Jason Rohweder
2017AH7	Conduct ecological assessment of enhanced aquatic areas--conduct analyses in Key Pools	30-Mar-17				Allison Anderson, Kristen Bouska, Jeff Houser, Alicia Weeks
2017AH8	Conduct ecological assessment of enhanced aquatic areas--complete draft report	30-Sep-17				Allison Anderson, Kristen Bouska, Jeff Houser, Alicia Weeks
2017AH9	Apply ecological relationships to entire system and incorporate into geodatabase	30-Sep-17				Tim Fox
Modelling future aquatic habitats						
2017FAH1	Develop Model in Key Pools	30-Mar-17				Jim Rogala
2017FAH2	Apply Model to entire system	30-Aug-17				Jim Rogala
2017FAH3	Draft report	30-Sep-17				Jim Rogala
Floodplain Habitats						
2017FH1	Develop water surface profiles and flood inundation models for the UMRS	30-Jan-17				Molly Van Appledorn
2017FH2	Refine/update levee and lidar data for isolated areas	28-Feb-17				Jason Rohweder
2017FH3	Analyze floodplain vegetation and forestry data	30-Apr-17				Molly Van Appledorn, Nate De Jager
2017FH4	Draft report	30-Sep-17				Molly Van Appledorn, Nate De Jager
2017FH5	Apply ecological relationships to entire system and incorporate into Geodatabase	30-Sep-17				Tim Fox
Modelling future floodplain habitats						
2017FFH1	Format/develop input datasets	30-Mar-17				Jason Rohweder
2017FFH2	Develop flood inundation model extension	30-Mar-17				TBA
2017FFH3	Conduct modelling and write draft report	30-Sep-17				Nate De Jager

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
Geodatabase						
2017GEO1	Develop Geodatabase/compile all lookup tables and data layers	30-Sep-17				Tim Fox
Landscape Pattern Research and Application						
2017L1	Presentations: Habitat Needs Assessment for the UMR (and related	30-Sep-17				De Jager
2017L2	Data/Map Set: Reed canarygrass abundance and distribution in the UMR (Pools 3-13) and areas at risk of invasion	30-Sep-17				De Jager, Rohweder, Hoy (UMESC)
On-Going						
2016L3	Draft Manuscript: Review of Landscape Ecology on the UMR	30-Sep-16	30-Sep-17		delayed due to work on the HNA-II	De Jager (UMESC)
2016L4	Draft Manuscript: Reed canarygrass abundance and distribution in the UMR.	30-Sep-16	30-Sep-17		delayed due to work on the HNA-II	Miller & Thomson (UW-L), De Jager Hoy and Rohweder (UMESC)
Intended for distribution						
Manuscript: De Jager, N.R., Rohweder, J.J. In Review. Changes in aquatic vegetation and floodplain land cover in the Upper Mississippi River System (1989-2000-2010). (2016L1) (in USGS Review)						
Manuscript: Swanson, W., De Jager, N.R., Strauss, E.A., Thomsen, M. In Review. Effects of flood inundation and invasion by *Phalaris arundinacea* on nitrogen cycling in an Upper Mississippi River floodplain forest. (2016L2) (in USGS Review)						
Manuscript: De Jager, N.R., Swanson, W., Hernandez, D.L., Reich, J., Erickson, R., Strauss, E.A. Effects of flood inundation, invasion by *Phalaris arundinacea* , and nitrogen deposition on extracellular enzyme activity in an Upper Mississippi River floodplain forest. (2015L5) (in USGS Review)						
Manuscript: Van Appledorn, M., De Jager, N.R., Johnson, K. Considerations for improving floodplain research and management by integrating inundation modeling, ecosystem studies, and ecosystem services (2016L5) (in USGS Review)						
Manuscript: Weeks, A.M., De Jager, N.R., Haro, R.J., Sandland, G.J. In Review. Spatial and temporal relationships between the invasive snail Bithynia tentaculata and submersed aquatic vegetation in Pool 8 of the UMR. (2016L6) (in USGS Review)						
Manuscript: Scown, M. W., Thoms, M. C. and De Jager, N. R. The effects of survey technique and vegetation type on measuring floodplain topography from DEMs. Earth Surface Processes and Landforms. (2015L8) (in USGS Review)						
Spatial Patterns of native mussels in the UMRS						
2016MRF1	Draft Completion report: Spatial patterns of native mussels in the UMRS	15-Sep-17				Ries, Newton, De Jager, Zigler
2016MRF2	Final completions report: Spatial patterns of native mussels in the UMRS	15-Nov-17				Ries, Newton, De Jager, Zigler
Pool 4 - Peterson Lake HREP Water Quality Monitoring – Pre and Post-Adaptive Management Evaluation						
2017PL1	Collection of pre-construction winter water quality data	1-Feb-17				Burdis, Moore, DeLain, Lund
2017PL2	Collection of pre-construction summer water quality data	1-Aug-17				Burdis, Moore, DeLain, Lund
2017PL3	Collection of post-construction winter water quality data	February 2018 – 2019(?) Dependent on construction date				Burdis, Moore, DeLain, Lund
2017PL4	Collection of post-construction summer water quality data	February 2018 – 2019(?) Dependent on construction date				Burdis, Moore, DeLain, Lund
2017PL5	Summary report: Tabular and graphical summary of water quality data	February 2018 – 2019(?) Dependent on construction date				Burdis, Moore

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
Pool 12 Overwintering HREP Adaptive Management Fisheries Response Monitoring						
2017P13a	Collect annual increment of pool-wide electrofishing data	1-Nov-16		1-Nov-16		Bierman and Bowler
2017P13b	Collect annual increment of fyke netting data from backwater lakes	15-Nov-16		15-Nov-16		Bierman and Bowler
2017P13c	Perform otolith extraction from bluegills for aging	1-Dec-16		1-Dec-16		Bierman and Bowler
2017P13d	Age determination of bluegills collected in Fall 2014	1-Feb-17				Bierman and Bowler
2017P13e	In-house project databases updated	31-Mar-17				Bierman and Bowler
2017P13f	Summary report compiled and made available to program partners	30-Sep-17				Bierman and Bowler
Pool 12 Overwintering HREP Adaptive Management Fisheries Response Monitoring – Pre-project Biological Response Monitoring; Crappie Telemetry –Kehough Lake						
2017AM1	Capture fish and affix radio tags to white crappies in study lakes	1-Nov-16		1-Nov-16		Bierman, Hansen, Bowler, Theiling
2017AM2	Location of tagged fish and update in-house project database	Ongoing through FY17				Bierman, Hansen, Bowler, Theiling
2017AM3	Complete tracking portion of study	30-Sep-17				Bierman, Hansen, Bowler, Theiling
2017AM4	Summary report: Analysis of tracking data and quantification of 80% UDs for Stone, Tippy, and Green lakes	30-Sep-17				Bierman, Hansen, Bowler, Theiling
2017AM5	Summary report: Analysis of tracking data and quantification of 80% UDs for Kehough lake	30-Sep-18				Bierman, Hansen, Bowler, Theiling
Understanding biological shifts in the UMR due to invasion by *Potamogeton crispus*-Year 2						
2016PC2	Draft Report: Understanding biological shifts in the UMR due to invasion by *Potamogeton crispus*	1-Jun-17				Drake, Giblin, Nissen, Kalas
Assessing recent rates of sedimentation in the backwaters of Pools 4, 8, and 13 to support river restoration and the Habitat Needs Assessment						
2017ST1	Reestablishment of horizontal and vertical temporary benchmarks, and	30-Mar-17				Rogala, Moore, Kalas, Bierman
2017ST2	Open-water nearshore surveys completed and a database	31-Jul-17				Rogala, Moore, Kalas, Bierman
2017ST3	Over-ice surveys completed and a database	30-Mar-17				Rogala, Moore, Kalas, Bierman
2017ST4	Data analysis and completion report on sedimentation rates along	30-Sep-17				Rogala, Moore, Kalas, Bierman
Developing and applying trajectory analysis methods for UMRR Status and Trends indicators – Year 2						
2015B16	Draft Manuscript: Fish Trajectory Analysis	30-Sep-16	28-Feb-17			Ickes, Minchin
2016B17	Draft Manuscript: Developing and applying trajectory analysis methods	31-Oct-17				Ickes, Minchin
Statistical Evaluation						
On-Going						
2016E2	Draft manuscript: How well do trends in LTRM percent frequency of occurrence SAV statistics track trends in true occurrence?	30-Sep-16	30-Sep-17			Gray
Intended for distribution						
Manuscript: Inferring decreases in among- backwater heterogeneity in large rivers using among-backwater variation in limnological variables (2010E1, Rogala, Gray, Houser) (In USGS review)						
Additional Aquatic Vegetation, Fisheries, and Water Quality Research--On-Going Work from previous Fiscal years						
Aquatic Vegetation Component						
2015A7	Data compilation and analysis: Aquatic macrophyte communities and their potential lag time in response to changes in physical and chemical variables	30-Jun-15	30-Dec-17		Eric Lund, new vegetation component specialist will be taking over this project	Lund
2015A8	Draft completion report or manuscript: Aquatic macrophyte communities and their potential lag time response to changes in physical and chemical variables in the LTRM vegetation pools	30-Jun-16	30-Jun-18		Eric Lund, new vegetation component specialist will be taking over this project	Lund

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
2016A6a	Draft manuscript: Aquatic Plant Response to Large-Scale Island Construction in the Upper Mississippi River.	30-Sep-16	31-Jan-17		Delayed due to modifications of models	Drake and Gray
2016A7	Draft completion report: How many years did the effects of the 2001-2002 Pool 8 drawdown on arrowheads (*Sagittaria latifolia* and *S. rigida*) last?	30-May-16	28-Feb-17			Yin
Fisheries Component						
2006B6	Draft manuscript: Spatial structure and temporal variation of fish communities in the Upper Mississippi River.	TBD				Chick
2016B14	Draft completion report: Exploring Years with Low Total Catch of Fishes in Pool 26	30-Sep-17	30-Sep-16		Delayed due to moving to new field station Bldg.	Gittinger, Ratcliff, Lubinski, Chick
Water Quality Component						
2015D15	Analysis of Lake Pepin rotifers; data from 2012-2014	30-Jun-15	30-Jun-17			Burdis
2015D16	Draft manuscript: Trends in water quality and biota in segments of Pool 4, above and below Lake Pepin	27-Feb-15	30-Jun-17			Burdis
Intended for Distribution						
Manuscript: Benefits of Collaboration among Long Term Fish Monitoring Programs in Large Rivers (Fisheries Journal) Counihan, Ickes, Casper, Sauer 2016B12 (in press Fisheries)						
Manuscript: An Assessment of Long Term Changes in Fish Communities within Large Rivers of the United States Counihan, Ickes, Casper, Sauer 2016B13 (resubmitting to PLOS One)						
Manuscript: Relationship between the temporal and spatial distribution, abundance, and composition of zooplankton taxa and hydrological and limnological variables in Lake Pepin; Burdis 2016D17 (Reformatting for submission to River Research and Applications)						
USACE UMRR LTRM Technical Support						
2017COE1	Quarterly update submitted to the LTRM Management Team	31-Dec-16		31-Dec-16		McCain, Theiling, Potter
2017COE2	Quarterly update submitted to the LTRM Management Team	30-Mar-17				McCain, Theiling, Potter
2017COE3	Quarterly update submitted to the LTRM Management Team	30-Jun-17				McCain, Theiling, Potter
2017COE4	Quarterly update submitted to the LTRM Management Team	30-Sep-17				McCain, Theiling, Potter
UMRR LTRM Team Meeting						
2017FM1	Meeting date coordination	16-Jan-17				All LTRM Staff
2017FM2	Agenda development	10-Feb-17				All LTRM Staff, led by UMESC
2017FM3	Meeting logistics	On-Going				Sauer
20157M4	Meeting participation	Week of March 27, 2017				All LTRM Staff
A-Team and UMRR-CC Participation On-going						

UMRR Science in Support of Restoration and Management

Recommended Proposals for FY2017

Page #	Proposal Title	PI	Cost
2	Estimating backwater sedimentation resulting from alluvial fan formation	Rogala	$23,875
5	Advancing our understanding of habitat requirements of fish assemblages using multi-species models	Bouska, Gray	$24,569
10	Investigation of metabolism, nutrient processing, and fish community in floodplain water bodies of the Middle Mississippi River	Sobotka	$30,349
21	Mapping the thermal landscape of the Upper Mississippi River: A Pilot Study	Jankowski & Robinson	$23,833

Upper Mississippi River Restoration (UMRR) Science in Support of Management for FY17

Title of Project:
Estimating backwater sedimentation resulting from alluvial fan formation

Previous LTRM project:
N/A

Name of Principal Investigator:
Jim Rogala
Agency: USGS – UMESC
Telephone: 608-781-6373
E-mail address: jrogala@usgs.gov

Collaborators (Who else is involved in completing the project):
Jenny Hanson
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Introduction/Background:
The need for information on sedimentation in the Upper Mississippi River System (UMRS) was established early in the planning for a monitoring/research component in what is now the Upper Mississippi River Restoration (UMRR) Program. Workshops held in 1994 and 2000 recommended a wide range of general investigations that might further inform resource managers on sediment transport and deposition of sediments in the UMRS (Gaugush and Wilcox 1994; Gaugush and Wilcox 2002). Several of the recommended investigations focused on better understanding rates of accumulation of sediment in backwaters, a known concern among most resource managers.

Sediment deposition in backwaters derives from two primary mechanisms: 1) deposition of fine sediment as it precipitates out from the water column and 2) deposition of near-bed coarse sediments delivered from adjacent channels. Some studies investigating fine sediment deposition have been done in the past, and at least some estimates of rates exist. In contrast, relatively little is known about the areas where sands are accumulating, or the rates at which they are accumulating.

Coarse sediment deposition in backwaters is often in the form of delta-like deposits (i.e., alluvial fans) where channels enter backwaters. Other depositional areas can be found as side channels enter into impounded areas in the lower portions of pools in the upper reaches. Sand deposits provide valuable habitat diversity, but at the expense of deeper water habitats. The accumulation of sand is a permanent deposition, whereas fine sediment deposits can be removed during future high flow events. Given the potential for altering backwaters in a permanent manner, a better understanding of alluvial fan formation is needed when considering future conditions of the UMRS.

Relevance of research to UMRR:
The general objective of this study is to determine the frequency and rate of alluvial fan formation in backwaters over a 20-yr period. This information complements ongoing backwater sedimentation studies by looking at one type of sediment accumulation that has been found to be significant in some backwaters. For example, during the North/Sturgeon HREP planning, several large alluvial fans were identified as features that have changed habitat substantially. A better understanding of the frequency and rate of alluvial fan formation provides the opportunity to assess whether these changes are desired, and if not desired, assess the types of habitat projects that might address the issue.

The proposed work address UMRR Strategic Plan (2015-2025) Objective 2.1 – Assess and detect changes in, the fundamental health and resilience of the Upper Mississippi River ecosystem by continuing to monitor and evaluate its key ecological components of aquatic vegetation, bathymetry, fish, land use/land cover, and water quality. Specifically, Strategy 2 within that Objective: Conduct scientific analysis, research, and modeling using UMRR's long term data, and any necessary supplemental data, to gain knowledge about the Upper Mississippi River ecosystem status and trends and process, function, structure, and composition

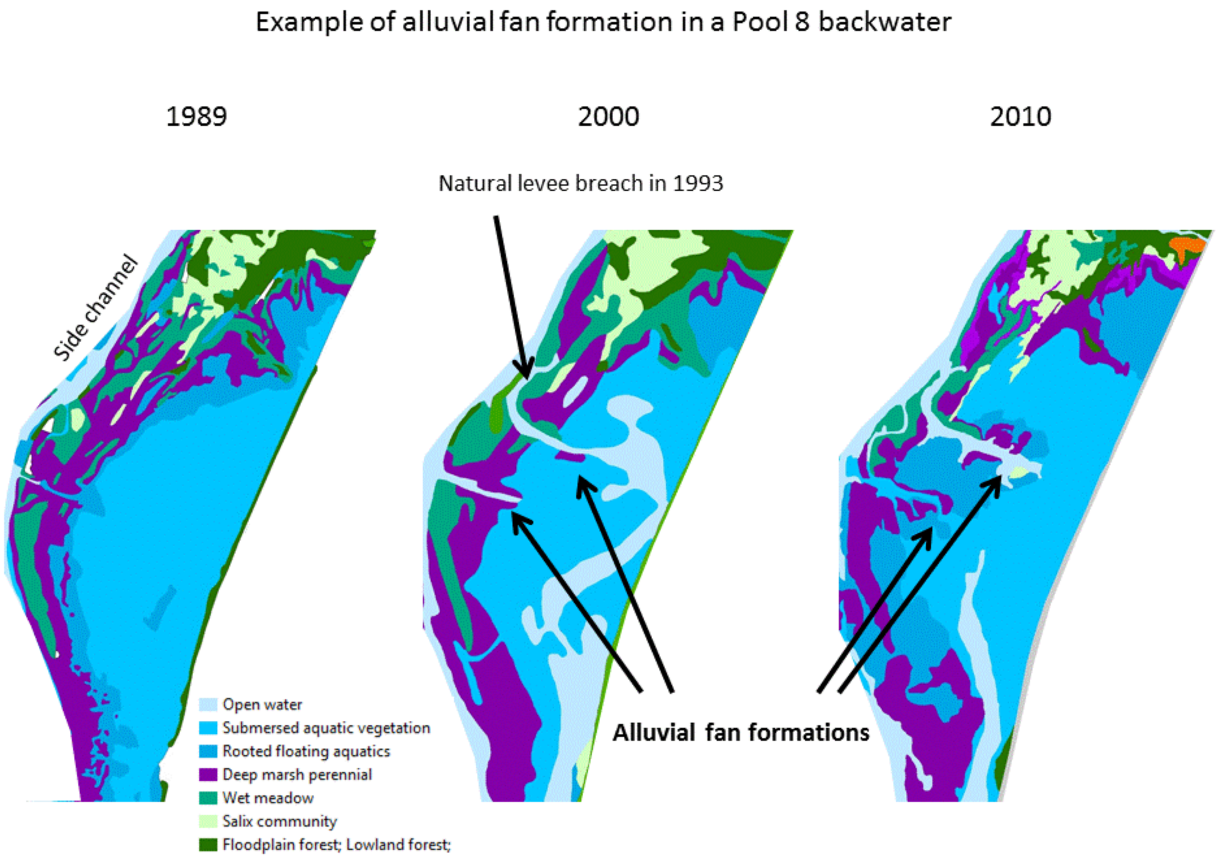
Methods:
In most cases, alluvial fan formation results in either very shallow water or a transition to terrestrial. This attribute provides an opportunity to evaluate, at least in a coarse manner, the changes by using remote sensing. Aerial photography can provide changes in land cover types that reflect changes from deep to shallow, and from aquatic to terrestrial. The UMRR has developed systemic land cover GIS data at a decadal scale (i.e., 1989, 2000, 2010), thus providing the opportunity to map alluvial fan frequency and magnitude for the UMRS.

This proposed pilot study will investigate the effectiveness of comparing the series of UMRR land cover datasets. The study will consider potential issues with spatial rectification, differences in mapping methodology, water level on the day of photography, and variation in land cover that may be a result of other variables. The pilot will be conducted in the upper three LTRM study reaches (Pools 4, 8, and 13). Maps of land cover changes that potentially reflect alluvial fan formation will be produced and analyzed to determine the frequency and magnitude of these features. The land cover changes mapped will include the more certain changes from aquatic types to terrestrial types (e.g., submergents to grass), but also include potential changes depicted by deeper aquatic types changing to shallow aquatic types (e.g., submergents to emergent). See the figure for an example of how a known alluvial fan formation is reflected in land cover type changes.

Budget:
UMESC - $23,875

Expected milestones and products [with completion dates]:

September 30, 2017 - Land cover GIS datasets identifying areas of potential alluvial fan formation
December 31, 2017 – Draft contract report summarizing findings and providing recommendations for expanding the project system-wide.


Example of alluvial fan formation in a Pool 8 backwater
1989
2000
2010
Natural levee breach in 1993
Side channel
Open water
Submersed aquatic vegetation
Rooted floating aquatics
Deep marsh perennial
Wet meadow
Salix community
Floodplain forest; Lowland forest;
Alluvial fan formations

Upper Mississippi River Restoration (UMRR) Science in Support of Management for FY17

Title: Advancing our understanding of habitat requirements of fish assemblages using multi-species models

Previous LTRM project:
This project advances our understanding of fish habitat requirements, thus building upon numerous previous projects. System-wide analyses of fish community structure have provided evidence that broad-scale differences in water clarity, water temperature, velocity and vegetation across LTRM reaches are associated with fish community structure (Chick et al. 2005; Chick et al. 2006). Similarly, reach-based analyses have identified important factors influencing fish community structure (Barko et al. 2005), and regional analyses have provided estimates of distributional responses to factors for a subset of the fish community (Ickes et al. 2014). Further, criteria representing seasonal overwintering habitat requirements of important game species have been identified (Palesh and Anderson 1990; Bodensteiner and Lewis 1992; Knights et al. 1995; Johnson et al. 1998; Bartels et al. 2008).

Name of Principal Investigator:
Kristen Bouska, UMESC, USGS, 608-781-6344, kbouska@usgs.gov
Brian Gray, UMESC, USGS, 608-781- 6234, brgray@usgs.gov

Collaborators (Who else is involved in completing the project):
PhD-level graduate student (to be hired); assist with fitting statistical models.

Introduction/Background:
<u>What's the issue or question?</u>
The identification and selection of habitat restoration projects within the UMRR are meant to address ecological needs representing a diversity of native species. The partnership has thus far advanced our understanding of the ecological needs for groups of species such as diving ducks, dabbling ducks, and Centrarchids. This understanding of habitat requirements for particular life history activities (i.e., migratory foraging habitat, overwintering habitat) is critical to maintain sufficient ecological conditions that, if limiting, may negatively influence populations. From a fish assemblage perspective, our understanding of habitat requirements for specific life-history activities is limited, though our understanding of life history guilds allows us to infer broad habitat needs. Yet, specific criteria are required to design rehabilitation projects for the objectives of habitat provision. The issue at hand is then how to identify habitat criteria to develop habitat restoration projects that benefit the broader fish community without undergoing species-specific analyses of all 140+ species?

Species archetype models cluster species based on their response to environmental gradients (Dunstan et al. 2011). We propose the use of archetype models with existing LTRM fisheries data to gain insight into habitat requirements across the fish community, with emphasis on environmental covariates that are commonly manipulated through Habitat Rehabilitation and Enhancement Projects (e.g., depth, velocity, temperature). The use of archetype models allows us to evaluate abundance and distribution responses to environmental gradients across species, allowing inference of community-wide habitat requirements. By generating clusters ("archetypes") by period, we can evaluate whether seasonal habitat associations align with hypotheses formulated based on our understanding of life history guilds. Further, if habitat associations do align with life history guilds, we can gain an understanding of life history attributes of poorly understood and possibly rarer species by borrowing information from similarly clustered, but well understood and more common species. Finally, by developing archetype models separately for study reaches, we can evaluate the variation in species-level responses and the diversity in fish community responses across reaches.

What do we already know about it?
Development of the UMRS fish life history database (O'Hara et al. 2007) allows us to group many of the common species into guilds from which we can infer broad habitat requirements. For example, in the spring and early summer, pelagophilic spawners require sufficient velocities to transport eggs long distances while phytophilic spawners require submerged vegetation and little to no velocity. Species-specific field investigations have provided further refinement of criteria that represent overwintering requirements (Bodensteiner and Lewis 1992; Knights et al. 1995; Johnson et al. 1998; Bartels et al. 2008). Additionally, regional single species distribution models have provided an understanding of important environmental covariates that influence distributions for a subset of the fish community; however, the authors suggested that reach/pool-scale models would be required to capture response curves for a larger suite of species (Ickes et al. 2014). The proposed work follows the aforementioned recommendation and combines it with a multi-species modeling approach to improve our understanding of habitat associations across the diverse fish community within the UMRS.

Why is it important?
Among the UMRS ecosystem restoration objectives is managing for a diverse and abundant native fish community (U.S. Army Corps of Engineers 2009). Critical to achieving this objective is characterizing the habitat requirements across the fish community.

Relevance of research to UMRR:
Objective(s) or hypothesis: The objectives of this work are to develop multi-species models from existing LTRM fisheries data to 1) identify the dominant responses to environmental gradients within the fish community of each study reach; 2) infer habitat requirements based on environmental responses and our current understanding of life history strategies; and 3) summarize response (archetype) diversity by reach. We hypothesize that seasonal species archetypes, driven by velocity and depth gradients, will relate to life history (e.g., spawning, foraging, overwintering) requirements. We also hypothesize that reaches with greater geomorphic and hydrologic complexity (i.e., habitat) will support a broader diversity of responses.

Relevance (demonstrate scientific and/or management value): Advancing our understanding of habitat associations of the broader fish community allows us to better define habitat needs within a reach and across the system. Further, the clustering of different species within archetypes based on their response to environmental gradients can provide an understanding of habitat requirements of poorly-understood species by making inferences based on similarly clustered, but well-understood species. By focusing on covariates that are commonly manipulated by restoration practices, implications of habitat restoration practices can be evaluated. Collectively, this information can provide managers the ability to more broadly estimate impacts and benefits of restoration projects on the fish community.

How the project enhances on-going work: Response (archetype) diversity can be used within the ongoing Resilience Assessment as an indicator of general resilience. From a habitat requirements perspective, this work complements on-going efforts within the Habitat Needs Assessment II.

How this work relates to needs of UMRR and river managers: The limited fundamental life-history information available on large-river fishes is considered to be a significant obstacle to managing riverine fish communities (Galat and Zweimuller 2001). This approach uses new techniques to gain insight into habitat associations across the fish assemblage and in doing so meets the guiding principles of the UMRR 2015-25 strategic plan (USACE 2015) by developing analyses that can be used to identify reach-scale habitat needs, habitat projects, and inform trade-off evaluations of habitat restoration projects (Objective 1.1). Additionally, changes in geomorphic and hydrologic complexity have impacts on species assemblages; understanding the gradients that fish are responding to can aid in understanding mechanisms of assemblage change across the system (Objective 2.2). Further, seasonal consideration of habitat associations allows for evaluation of life history-specific requirements. For example, fall (period 3) sampling may provide unique habitat associations to infer overwintering requirements, complementing existing research framework efforts (Ickes 2005). Finally, the proposed work supports the broad goal of restoring and maintaining the diverse native fish fauna by improving our understanding of habitat requirements (UMRCC 2010).

Methods:
We will evaluate species responses to environmental gradients within sampling periods using models that capitalize on similarity of responses among species. For example, our data might suggest responses to flow and temperature by bluegill and black crappie are similar relative to those by emerald shiner and bigmouth shiner.
These multivariate models, termed 'species archetype models,' are treated as improvements over fitting multiple single-species models for two reasons. First, fitting multiple single-species models may be impractical from a logistics perspective, and may also yield results that may be difficult to interpret in a multi-species context. By contrast, the multivariate species archetype models (SAMs) provide summaries across species (even while offering species-specific estimates). Second, the multivariate models acknowledge the reality that species responses to environmental covariates may be correlated; capitalizing on this correlation by using a multivariate model improves conclusions, and particularly so for rare species (by grouping them with prevalent species having statistically similar responses; Hui et al. 2013).

SAMs also offer improvements over algorithmic site-based approaches such as multidimensional scaling often used by ecologists. The former may be more appealing to science-based agencies than the latter because SAMs attempt to approximate ("model") the processes that yielded the data, and because not attempting to approximate those processes may lead to incorrect conclusions (Warton et al. 2012). Note that each archetypal response in a SAM represents a group of species that responds to environmental gradients in a statistically similar way. Communities observed at a site may be viewed as being comprised of multiple overlapping species distributions and, hence, archetypes, that, in turn, generate a unique assemblage at that one location (Dunstan 2013). SAMs have been used to evaluate fish species and fish species archetype associations with environmental gradients using count and biomass data

(Dunstan et al. 2013). More about SAMs may be found in Dunstan et al. (2013) and Hui et al. (2013).

We will use LTRM fish data from day electrofishing in 2015 from all strata in Pool 8 and the Open River reach. We will model both species detection/nondetection data as well as species counts. Multi-species responses will be modeled as functions water temperature, velocity, turbidity and depth. The potential for stratum effects, after adjusting for all covariates will be evaluated; if present, those effects will be addressed by including stratum effects. We will follow an elaboration of the SAM model described by Dunstan et al. (2013) that allows for period-specific archetypes to vary by sampling period

Special needs/considerations, if any: Opportunities to select a qualified graduate student will be greatest if funding can be assumed as many months as possible before summer (June).

Budget: $24,569 for FY17 for graduate student. USGS PIs are contributing work in kind.

Timeline:
Latest date for beginning of project: 1 Jul 2017.
Expected completion date: 12 months after receipt of funds

Expected milestones and products: Draft report on period-specific inferences on environmental gradients (12 months following receipt of funds). This report will describe species-environment associations by period.

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Upper Mississippi River Restoration (UMRR) Science in Support of Management for FY17

Title of Project: Investigation of metabolism, nutrient processing, and fish community in floodplain water bodies of the Middle Mississippi River.

Previous LTRM project: N/A

Name of Principal Investigator:
Molly Sobotka
Missouri Department of Conservation
573-243-2659 ext 1048
Molly.sobotka@mdc.mo.gov

Collaborators (Who else is involved in completing the project): none

Introduction/Background:

Floodplains are a vital component of large river ecosystems. Floodplains provide refuge areas for sensitive and juvenile aquatic organisms during flood events and increase ecosystem diversity by providing variable habitats (Ward et al 1999). As the floodplain undergoes cycles of connectivity nutrient processing and sediment capture occurs, removing potential pollutants from the system (Noe and Hupp 2009, Kroes et al 2015). Distribution of water bodies across the floodplain results in a suite of backwaters, channels, and lakes with different connectivity regimes. River control structures have disconnected the Middle Mississippi River from over 80% of its historic floodplain. In many areas this has resulted in a narrow floodplain with limited connectivity to floodplain water bodies. Personal observation does suggest that a connectivity regime exists even within the restricted floodplain. However, very little is known about how these water bodies function independently and as part of the greater Mississippi River system. This information is needed by managers in order to effectively restore limited functional processes (i.e. HREP) or manage floodplain habitats.

Relevance of research to UMRR:

We propose to examine floodplain water body function across a gradient of connectivity to the main river. This pilot study will explore fish and aquatic invertebrate community structure, nutrient depletion, and ecosystem metabolism in off-channel areas that span a gradient of connectivity. We hypothesize that decreasing connectivity to the main river will result in more unique fish assemblages and more lentic water quality conditions. Further, we expect nitrogen concentrations to decrease as water bodies become disconnected from flood waters or the main channel and as primary productivity in the water column increases (Sobotka and Phelps 2016).

Other data sources suggest that these backwater habitats function very differently. For example data collected from a backwater (the Blew Hole) in the Open River reach of the Middle Mississippi River (MMR) suggests a different fish community is using this off-channel habitat (including species of interest to the public e.g. Centrarchids) however the size of this backwater has decreased by 50% since 1993 due to sedimentation. Additionally, no water quality data has been collected at this location. Another larger backwater was created during the record-breaking flood 2015. This provides us with an excellent opportunity to collect data as that backwater community is established.

The Army Corps of Engineer Research and Development Center (ERDC; Vicksburg, MS) is currently working with partners in the Lower Mississippi River floodplain to understand the relationship between river- floodplain connectivity (spatiality and temporally) and biota (fish, invertebrates, and allochthonous/ autochthonous contributions to the riverine ecosystem). Our methods are designed to complement portions of that study.

1. Scientific Framework for Landscape Patterns research on the Upper Mississippi and Illinois River Floodplains

Objective 1: Developing structural measures of landscape pattern

1.4. Patterns of aquatic area richness

- This study would provide ground-truthing for measures of limited habitat heterogeneity (e.g. do existing floodplain lakes in the MMR function differently from secondary channels based on fish community or water quality).

Objective 2: Examining the ecological consequences of landscape patterns

2.2 Floodplain soil nutrient dynamics

- This study would provide estimates of relative nitrogen processing rates as well as over-all nitrogen capture in backwater, side-channel, and lake water bodies.

2.3 Aquatic community composition

- This study would result in fish community data across a gradient of floodplain water bodies and allow preliminary assessment of the relationship between fish community and structural heterogeneity in the floodplain.

2. Indicators of ecosystem health for the Upper Mississippi River system

4.7.6 Species Richness [Community Structure]

- This study would sample the fish community associated with water bodies that can become disconnected from the main river. The floodplain may be a source of rare species to the main river.

5.4.1 Backwater fishes assemblage

- While the Open River Reach lacks backwater habitat similar to that found in the pooled river there are habitats that may be used by a backwater fish assemblage which are not sampled by LTRM. These include floodplain water bodies minimally or infrequently connected to the main river. This study would sample the fish community associated with these water bodies. The floodplain may be a source of these species to the main river.

3. **UMRR Strategic plan 2015 – 2025**

Goal 2: Advance knowledge for restoring and maintaining a healthier and more resilient Upper Mississippi River ecosystem

Objective 2.1: Assess, and detect changes in, the fundamental health and resilience of the Upper Mississippi River ecosystem by continuing to monitor and evaluate its key ecological components of aquatic vegetation, bathymetry, fish, land use/ land cover, and water quality. Strategy 2, Strategy 4

- The gradient of floodplain habitat is a critical component of large river ecosystems however the LTRM is not designed to sample these habitats. This study will allow researchers to better understand the floodplain as a refuge habitat for sensitive or juvenile fishes and how nutrient cycling processes are influenced by flooding. An understanding of connectivity between the floodplain and the MMR main river is important in assessing the resiliency of the system.

Objective 2.2: Provide critical insights and understanding regarding a range of key ecological questions through a combination of monitoring, additional research, and modeling in order to inform and improve management and restoration of the Upper Mississippi River ecosystem.
Strategy 1, Strategy 4

- This study will provide information critical to understanding how connectivity influences fish community and physio-chemical processes. Managers need this information to better design restoration projects to meet their goals (e.g. restoration efforts aimed at reducing nutrient transport during flooding).

Methods:

1. Quantify connectivity of floodplain water bodies to the main channel (Oliver et al 2016).
    a. Using topobathy GIS layers we will identify connection cut-off points between the main channel and selected water bodies. These cut-offs will be used in conjunction with elevation data from the nearest river gage to assess frequency of connectivity.
    b. Pilot water bodies with frequent (permanent or near permanent), intermediate (connected < 100 dpy), and rare (connected < every 5 years) connectivity regimes will be selected for initial study.
    c. Timing of connection will be monitored during the study period.
2. Collect fish and invertebrate community data from selected floodplain water bodies.
    a. We will use best available gear depending on water body structure. Effort will be standardized across gears.
        i. Seining, hand trawl, and electrofishing (fish).
        ii. Ponar (invertebrates).
    b. Sampling will occur once a month between March and August 2017. Sampling will also occur before and after large flood events.
3. Water quality metrics will be collected monthly or bi-monthly between March and August 2017.
    a. Sampling will occur in conjunction with regularly scheduled LTRM fixed site sampling.
    b. TSS and VSS samples will be analyzed at the MDC Big Rivers and Wetlands laboratory using UMESC procedures.
    c. Total nitrogen and dissolved inorganic nitrogen samples will be analyzed at the UMESC laboratory.
    d. Oxygen and temperature profiles will be collected to quantify stratification.
4. Continuous dissolved oxygen and temperature data will be collected from each water body as well as light extinction data.
    a. These data will be used to model ecosystem metabolism at each site (Sobotka and Phelps 2016).
5. Results of fish community surveys and water quality metrics will be compared using non-metric multivariate methods to identify differences between water bodies. Floodplain data will be compared to LTRM water quality and fish component data to evaluate differences between the main channel and floodplain habitats. Nutrient and metabolism data will be correlated to assess nutrient capture and depletion rates.
6. This is a one year study. If findings are promising we propose to increase sampling across additional water bodies and river reaches.

Special needs/considerations, if any: none

Budget:
$29,565 for MDC temporary staff and sample processing.

Timeline:

- Completion of pilot sampling effort: (dependent on flooding) estimated August 2017
- Completion of data analysis October 2017

Expected milestones and products:

- August 2017: project completed, fish and water quality databases
- December 2017 report completed. Report will detail differences between the floodplain habitats and the main channel. We will further associated fish community and water quality attributes with connectivity of the water body to floodwaters or the main channel.

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Mapping the thermal landscape of the Upper Mississippi River: A Pilot Study

Principle Investigators: KathiJo Jankowski & Larry Robinson (UMESC)
Collaborators: Janis Ruhser (UMESC), Brian Lubinski (USFWS)

Temperature is a master variable that controls physical, chemical and biological processes in aquatic ecosystems. For instance, temperature influences fundamental physical characteristics of water such as its density and movement; controls the rates of biogeochemical processes important to river functioning such as nitrogen and carbon cycling (Allen et al. 2005, Yvon-Durocher et al. 2012, Jankowski et al. 2014); and affects all aspects of organism physiology including growth, feeding, and reproduction (Arrhenius 1889, Brown et al. 2004). Thus, shifts in the thermal environment can have effects across all scales of ecological organization.

Temperature dynamics in fluvial systems respond to a diverse array of drivers (Caissie 2006). The natural geomorphic template of a river establishes the basic processes that influence spatial and temporal patterns in temperature, such as elevation, river width, water residence time, light availability, and groundwater input. For instance, although we generally expect that average river temperature will increase with stream order, recent work has shown that longitudinal thermal regimes can vary across rivers depending on catchment geomorphology (Fullterton et al. 2015) or dominant water sources (i.e., snow, rain, or groundwater; Lisi et al. 2013). In addition, depending on floodplain morphology and river flow, complicated thermal patterns can develop laterally across river floodplains and backwater habitats that are important for several life stages of river biota (Figure 1; e.g., Tonolla et al. 2010). In many cases, however, river thermal regimes have been altered by anthropogenic activities such as dams or channelization, thermal inputs from industrial sources, or the removal of riparian forest cover. Therefore, understanding the both the natural and anthropogenic drivers of thermal patterns in rivers is fundamentally important to understanding how they will respond to future changes in land use and climate.

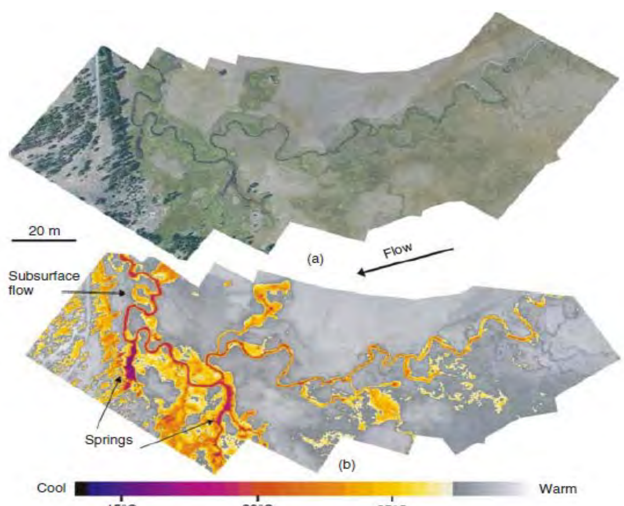

Figure 1. Thermal image of the upper Middle Fork John Day River (Oregon, USA) showing complex temperature patterns across the floodplain, location of groundwater springs, and occurrence of subsurface flow (image from Handcock et al. 2012).

Recent work has shown that the Mississippi River is one of the most thermally polluted rivers globally (Raptis et al. 2016) and that like many other rivers and streams across the US (Kaushal et al. 2010), the Upper Mississippi may be warming over time (LTRM, unpublished data; Figure 2). This has important implications for all aspects of river functioning and management including the availability of thermally suitable habitat for fish, rates of biogeochemical processes that control nutrient availability, and can even have implications for human health through increasing the frequency and extent of blooms of toxic cyanobacteria (Paerl and Paul 2012).

The LTRM element of the UMRR program has an extensive dataset on river temperatures from the last 25 years (Figure 2). The current dataset includes fairly high temporal resolution temperature data from fixed sites (~every 2 weeks for 25 years) and high spatial resolution temperature data from SRS episodes (point measurements across multiple strata 4x per year). While these data provide a number of pieces of important information (e.g., estimation of annual and long-term trends, understanding patterns in temperature across strata), they are limited in providing some key information. For example, the spatial resolution of current data do not allow us to quantitatively map the availability of thermal habitats across the river. This is turn limits how well we can assess the influence of habitat restoration projects on thermal dimensions of habitat quality. Furthermore, the temporal scale of our current dataset limits our ability to assess how temperature responds to shorter term drivers (storm events/high flow events) that affect the thermal environment at shorter time scales (hours, days, weeks) and inform our understanding of how the river will respond to shifting precipitation patterns and warmer temperatures.

Therefore, we propose a pilot study to evaluate the spatial and temporal dynamics of temperature in the UMR. We will use a combination of airborne thermal infrared remote sensing (TIR) and an array of in-situ temperature loggers to map surface temperature across habitats and seasons in Pool 8 the UMR. TIR has been used widely in riverine habitats for diverse applications such as mapping groundwater inflows (Figure 1; Loheide and Gorelick 2006), coldwater refugia (Torgersen et al. 2001, Hancock et al. 2012), thermal pollution (Raptis et al. 2016), and mapping river-floodplain connectivity (Tonolla et al. 2010). As far as we know, however, TIR has not been used to map spatial patterns in temperature in a river as large and complex as the UMR. These data can be turned into a "river thermal-scape" GIS layer which can be directly linked with existing spatial layers for the river such as bathymetry, vegetation, and land cover data to inform our understanding of spatial patterns and habitat availability.

Thus, these data will fill important gaps in our understanding of temperature dynamics of the river, including how the physical dimensions of the river influence thermal regimes, how thermal habitat is distributed across the landscape and how river temperatures respond to change at short time scales. Specifically we will ask the following questions:

1. How does temperature vary spatially across the diverse habitat types of Pool 8?
2. Do temporal patterns differ across habitats (e.g., rate of warming in the spring, cooling in the fall)? What controls these differences among and within habitat types?
3. How does connectivity among habitats (e.g., backwater & main channel) influence spatial and temporal patterns in temperature?

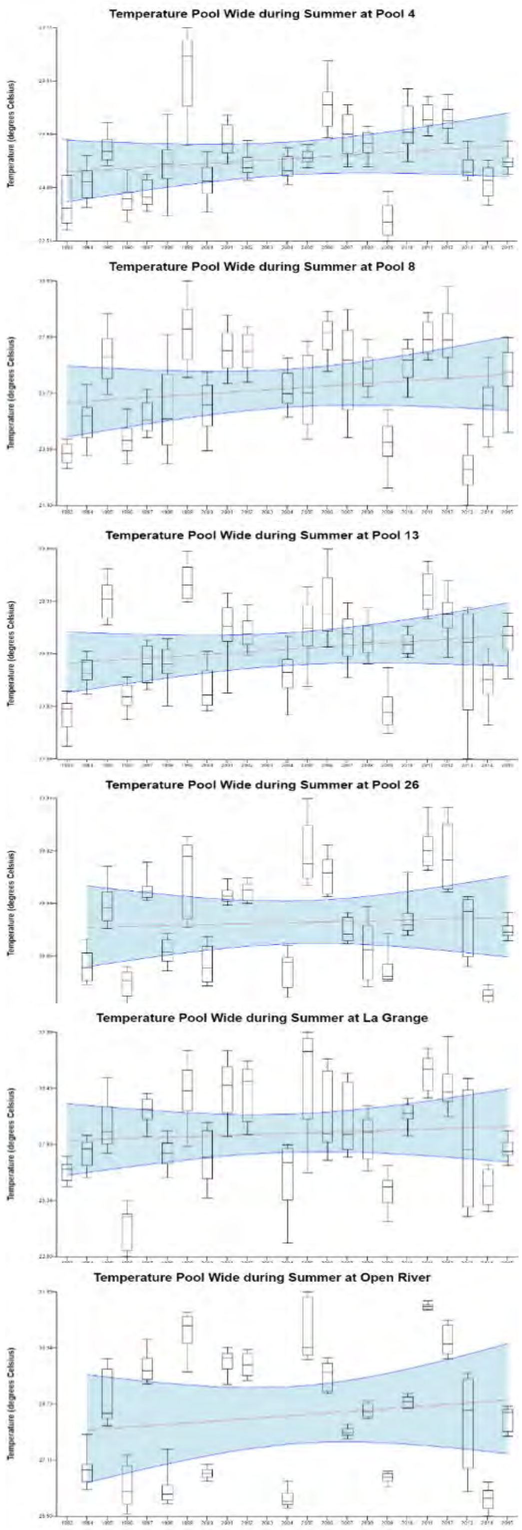

Figure 2. Median temperatures in all UMR Study pools from 1993-2015. (Data & figures generated from LTRM Graphical Water Quality Database Browser).

Methods:

We will collect airborne thermal and natural color imagery and deploy continuous temperature loggers during the Spring and Summer SRS sampling events in Pool 8 of the UMR. Synchronizing our imagery collection with SRS sampling events will allow us to spatially map water quality data onto both thermal and visible imagery at two contrasting river stages. The visible imagery will provide context for thermal signatures. This is being proposed as a Pool 8 specific project because there are several issues to consider and methods to develop (discussed below) before applying airborne thermal imagery to generate reliable temperature data across broader portions of the UMR.

<u>Airborne Imagery</u>:

To collect imagery, we will use a cooled, mid-wave infrared (3.0-5.0 microns) FLIR SC8343 camera and a Phase One iXU-R 180 digital aerial camera. The SC8343 is a high-definition fixed camera with a 1,280 x 720 pixel sensor. A 25mm lens will be used at an altitude of 915 meters, generating 14-bit thermal imagery at 0.5 meters per pixel. The Phase One iXU-R is an 80-megapixel camera that uses a 10,328 x 7,760 pixel visible light sensor. The iXU-R 180 will use a 70mm lens and collect imagery at a resolution of 0.07 meters per pixel (~3" per pixel).

Both cameras are installed in the U.S. Fish and Wildlife Service (FWS) Migratory Bird Program's (MBP) Partenavia P68 Observer aircraft and tightly integrated into the plane's position and orientation system. This allows the camera to record an image event with precise latitude, longitude, altitude, roll, pitch, and heading for every exposure collected and the gyro-stabilized mount ensures that all imagery is nearly perfectly vertical and isolated from engine vibration. Geographic information system (GIS) and image processing software can use this information to mosaic hundreds or thousands of single images into seamless and GIS-ready orthorectified mosaics.

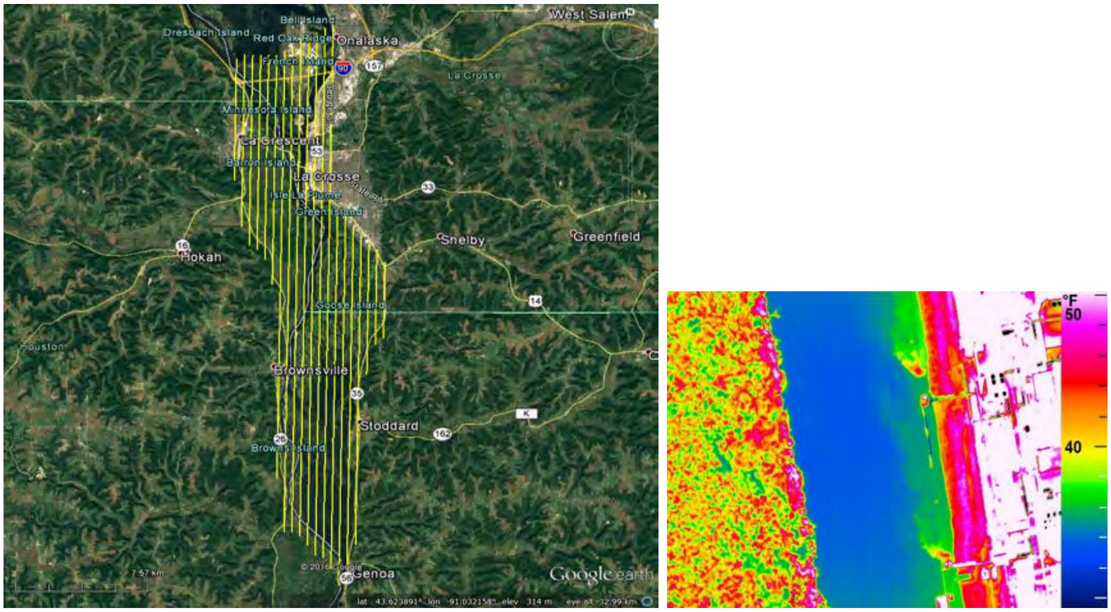

Figure 3. The thermal infrared flight plan for Pool 8 of the Upper Mississippi River will take approximately three hours to collect 20 lines of imagery at a resolution of 0.5 meters per pixel. Inset image shows a power plant outflow into the Mississippi near Clinton, IA (image: Larry Robinson).

The SC8343 thermal camera uses a mid-wave sensor which records both reflected and emitted energy. For this reason, we will collect all imagery in the morning when the river's surface is typically calmer and the sun is lower on the horizon, reducing the potential for sun glare and surface turbulence. Thus, the water surface temperatures should be more reflective of actual temperatures than later in the day when the sun and wind will have a greater effect on the accuracy of image data. The flight plan, shown above in Figure 3, will take approximately three hours to collect 20 lines of imagery, thereby minimizing the potential for temperature change over time.

We will post-process the positional information documented for each image using Applanix POSPac MMS to remove errors in the GPS signal and determine sensor attitude (omega, phi, kappa) recorded by Partenavia's gyro-stabilized camera mount. Each frame can then be referenced to the earth's surface using Inpho's OrthoMaster, and mosaicked into a single image with ERDAS Imagine MosaicPro. **The final products will be a 14-bit TIFF-format thermal mosaic that contains surface temperature readings and a natural color mosaic collected simultaneously.**

<u>Temperature Loggers</u>:
In order to ground-truth imagery information and to generate more fine-scale temporal temperature data, we will install continuous temperature loggers at surface depth (0.2m) at 15 fixed sites in pool 8 (Hobo Water Temp Pro v2, Onset Corp, Onset, MA) prior to the initial flight in April 2017. These loggers will remain deployed at least for one year. In addition, the UMR is a deep enough river that there is potential for vertical temperature stratification in several locations which may limit the utility of surface

temperature data. This pilot study will allow us to test and account for how widespread and influential its effect may be.

Therefore, we will deploy temperature loggers at depth at a subset of fixed sites to evaluate the occurrence of vertical stratification. To assess how widespread this is across Pool 8, we will use the approach of other authors that have applied Reynolds numbers (Torgersen et al. 2001) which combine temperature and velocity data to assess the potential for thermal stratification of water. Furthermore, LTRM data suggest that stratification typically occurs at velocities under 0.1 m/s, thus we can use historic profiles to assess the spatial distribution of stratification as well (Soballe and Fischer 2004).

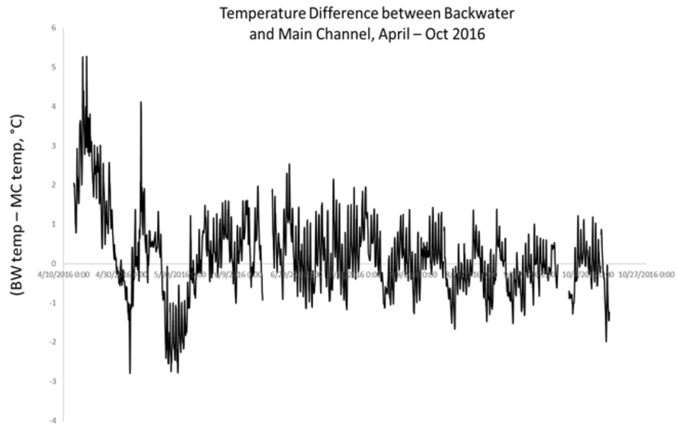

Figure 4. Differences in daily temperatures as measured by Main channel and Stoddard GREON buoys from April – October 2016. (J. Houser, unpublished data).

<u>Budget</u>
UMESC - $22,423 (PI in kind, includes USFWS flight cost)
WI DNR field station - $1,410
Total $23,833

<u>Expected Products/Outcomes</u>
This project will generate high spatial-resolution temperature layer for Pool 8 in TIFF image and Esri GRID formats and high temporal-resolution temperature data at fixed sites in Pool 8 as raw data and as an Esri shapefile. These data will allow us to link spatial temperature patterns to other existing spatial data including depth, flow, land cover and vegetation as well as spatially-referenced water quality data obtained during the two SRS sampling events. By doing two overflights, we will be able to assess the influence of river stage on the temperature distribution of Pool 8. Furthermore, high resolution temporal data distributed across the pool will provide information on how and why temperature may vary differently among habitats and help to identify important drivers (Figure 4).

<u>Timeline</u>
<u>April, 2017</u>: Deploy temperature loggers; Acquire thermal and visible imagery of Pool 8;
<u>May 2017:</u> Thermal and visible image processing and mosaicking;
<u>August, 2017</u>: Summer thermal and visible imagery acquisition of Pool 8;
<u>September, 2017</u>: Thermal and visible image processing, mosaicking, and analysis;
<u>December, 2017</u>: Draft report on feasibility and utility of surface water temperature map
<u>January, 2018</u>: Final report and data distribution.

<u>Relevance and future applications for the UMRR</u>
There are several other potential applications for these types of data that would apply to Goal 2 of the UMRR Strategic Plan (USACE 2015): "Advance knowledge for restoring and maintaining a healthier and more resilient Upper Mississippi River ecosystem". Specifically, this project fits within Objective 2.2 to

"Conduct focused research and analyses to gain critical, management-relevant information about the UMR ecosystem's process, function, structure and composition as well as the dynamics and interactions among system components". For example, these data could enhance understanding of connectivity among habitats, assist with mapping the spatial extent of the impact of HREPs on thermal habitat, provide maps of potentially suitable fish habitat during key periods of the year (larval fish production/nursery habitat in spring; thermal habitat availability in the fall at the time of staging for over-wintering; availability of summertime thermal refugia for cool water species), and potentially link temperature spatially with harmful cyanobacterial blooms. This project would allow to explore the utility of thermal imagery for these type of applications in the UMR.

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Fish Indicators of Ecosystem Health: Upper Mississippi River System

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Executive Summary

Following the recommendations of the LTRM Indicator Report (Hagerty and McCain 2013), we have evaluated the use of two fish community health indicators: migratory species and backwater assemblages. Membership into the migratory species indicator was determined by information compiled by UMRR LTRM personnel in the UMRR LTRM Life History database (O'Hara et al. 2007). This comprehensive list was reduced to an exclusive list of UMRS migrants comprised of sturgeon species (i.e., Pallid, Lake, and Shovelnose), American eel, Paddlefish, Alabama shad, Skipjack herring, and Blue sucker. This reduced list of UMRS migrants are thought to be directly impacted by the navigational dams and are being used to compile the migratory indicator. The species that comprise this list are rarely captured in Pools 4, 8, and 13, which results in indicator catch-per-unit effort (CPUE) values near, or at, zero for the majority of UMRR LTRM element day-time electrofishing history. In Figure 1 (right), the annual CPUE of the migratory fish are represented for the Open River Reach.

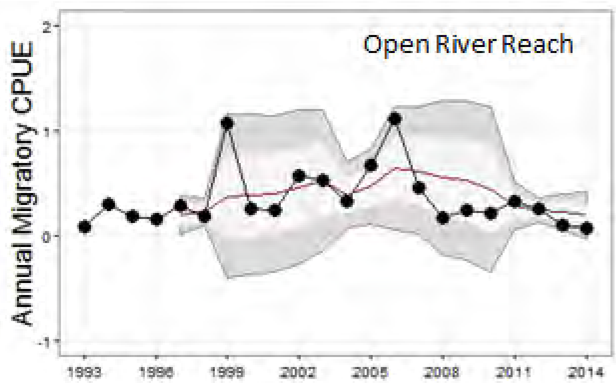

Figure 1: Ecosystem health status of UMRS migrant fish species was evaluated using pool-wide annual catch-per-unit-effort (CPUE; black line) compared to 5-year moving average trends (red line). The shaded areas represent 1- and 2- standard deviations around the 5-year moving average.

Membership into the backwater assemblage indicator was determined using statistical analysis (i.e., Indicator Species Analysis; Dufrene and Legendre 1997) which objectively classified species into each stratum across the UMRR. Indicator species analysis assigns an indicator value (IndVal) to each taxon. The indicator value is the product of two conditional probabilities, specificity and fidelity. Specificity is the probability that the surveyed site belongs to the target site group (i.e., strata) given that the species has been found. Fidelity is the probability of finding the species in sites belonging to the site group. Species with significantly ($p \leq 0.05$) high indicator values for a given group have a high probability of being found in other samples within the same habitat strata. This suggests an affinity by that species for environmental

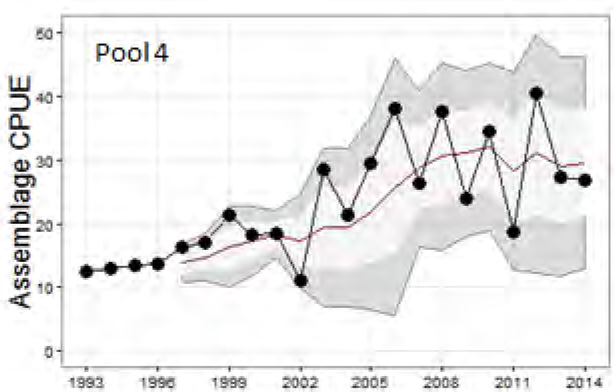

Figure 2: Ecosystem health status of backwater assemblages (Table 2) was evaluated using backwater strata annual catch-per-unit-effort (CPUE; black line) compared to 5-year moving average trends (red line). The shaded areas represent 1- and 2- standard deviations around the 5-year moving average.

characteristics common to specific strata. Prior to analysis, all non-native species to the UMRS were removed. All gear types across all sampling periods were used in order to generate a backwater assemblage indicator lists that were not bias towards organisms size, life history stage, or movement. The final backwater indicator list is comprised of 28 species ranging from commonly thought of backwater species such as Bluegill and Black crappie, to smaller bodied species, such as Golden shiner, and ancient species, such as Bowfin. Pools 4 (Figure 2; above) and 8 are the only RTAs in which an increase in CPUE (day-time electrofishing) of the backwater assemblage indicator has been observed. The Open River and La Grange Reaches show declines in CPUE over time. Highly reduced catches in the Open River is due to the lack of available backwater habitats in this RTA in which no backwater strata are currently sampled under UMRR LTRM protocols.

In order to quantitatively assess the ecological health status of the UMRS, we adopted an interpretive framework which utilizes the robust long-term dataset generated by the UMRR LTRM element. Instead of using a traditional reference condition approach, we focused on identifying when a meaningful change has occurred within each RTA despite natural variability and background noise. For each indicator metric (i.e., migratory and backwater assemblages) within each RTA we used a 5-year moving average to set a baseline internal "reference" condition. In addition, we used the moving average ± 1 and 2 standard deviations to serve as concern and target thresholds. We utilized 1 and 2 standard deviations in order to capture 68% and 95% of the observations, respectively. This helps ensure that any samples outside of the 2 standard deviation range constitutes a significant change in the indicator outside of an expected range based on what was observed the previous years. Further management action or additional research may be needed in RTAs in which samples are outside of the expected range in a negative direction for consecutive years. Indicator target values should, at minimum, be within the 1 standard deviation around the 5-year moving average on an annual basis. However, it may be desirable that an indicator exceed 1 standard deviation of the 5-year moving average with significant indicator changes occurring beyond 2 standard deviations. If an indicator 5-year moving average is trending in a negative manner and has exceeded the 2 standard deviations, then management intervention or additional research may be needed to determine causes of decline.

ATTACHMENT D

<u>Habitat Restoration</u>

- **Draft Manuscript re Conceptual Relationships of UMRS Ecological Resilience (12/21/2016)** *(D-1 to D-36)*

Full title: **Developing a shared understanding of the Upper Mississippi River: the foundation of a resilience assessment**

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ABSTRACT

The Upper Mississippi River System (UMRS) is a large and complex floodplain river ecosystem that provides opportunities and challenges for the application of resilience thinking to ecosystem understanding and management. In support of ongoing ecosystem restoration and management by a broad partnership of state and federal agencies, we are undertaking a resilience assessment of the UMRS. Here we describe the UMRS in the context of ecological resilience concepts. Our description articulates the temporal and spatial extent of our assessment of the UMRS, the relevant historical context, the valued services provided by the system, and the fundamental controlling variables that determine its structure and function. We conceptualize a simplified UMRS as three interconnected subsystems: lotic channels, lentic off-channel areas, and floodplains. By identifying controlling variables within each subsystem and the interactions among subsystems, we have developed a shared understanding of the basic structure and function of the UMRS, which will serve as the basis for ongoing quantitative evaluations of factors that likely contribute to the resilience of the UMRS. Through understanding the interactions, feedbacks, and critical thresholds within the system, natural resource managers can better recognize the system's ability to adapt to existing and new stresses.

Keywords: Ecological resilience; stressors; controlling variables; system description; large floodplain river

INTRODUCTION

As anthropogenic pressures increasingly affect ecosystems, there is growing interest in applying concepts of ecological resilience to ecosystem management. Ecological resilience has been defined as "the capacity to absorb disturbances and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks" (Holling 1973; Walker et al. 2004). The theory associated with this definition maintains that ecosystems are self-organizing, meaning that within limits, interactions and feedbacks maintain an ecosystem's state or regime (Levin 1998; Walker and Salt 2012). Disturbances or changes that move ecosystem components across critical thresholds can result in abrupt and unexpected shifts to alternate states that are subsequently maintained by novel interactions and feedbacks (Holling 1973; Gunderson 2000). Therefore, managing an ecosystem for resilience requires anticipation of critical thresholds, understanding feedbacks and interactions at different scales, and embracing variability and uncertainty (Allen et al. 2011).

The Upper Mississippi River System (UMRS) is a model ecosystem for the application of resilience concepts. Ecologically, the system is diverse, supporting over 140 fish species (Garvey et al. 2010) and serving as a continentally important migratory corridor for waterfowl (Beatty et al. 2015). Such high levels of biodiversity are thought to be supported by a generally high degree of spatial and temporal variability in both habitat (De Jager and Rohweder 2011) and hydraulic connectivity (De Jager and Houser 2016). Yet there are strong differences in degrees of connectivity and biodiversity across the system, and slow variables, such as cumulative inputs of nutrients and suspended sediments and the resulting sedimentation in off-channel areas, have consequences across the entire system. From a management perspective, the UMRS is studied, monitored, and managed by a diverse group of agencies that interact in a collaborative manner under the U.S. Army Corps of Engineers' Upper Mississippi River Restoration Program (UMRR). Five states, multiple federal agencies and numerous local authorities are responsible for managing the river for a wide range of often-conflicting uses (Fremling 2004). No single agency can claim jurisdiction or management responsibility for the river system and as a result no single objective dominates management. Instead, management objectives have been developed for a wide-range of geomorphic, hydraulic, biogeochemical, and biotic processes and endpoints (U.S. Army Corps of Engineers 2011).

Recently, the UMRR adopted a vision for "a healthier and more resilient ecosystem that sustains the river's multiple uses" (Upper Mississippi River Restoration Program 2015). In support of that vision, the UMRR partnership is undertaking a resilience assessment. Resilience assessment frameworks have been developed over the past decade to operationalize resilience concepts in the context of natural resource management (Quinlan et al. 2016). These frameworks provide a sequence of strategic questions that aid in developing a shared understanding of how a system functions and identifying the key controlling variables that influence ecosystem function and services (Resilience Alliance 2010; O'Connell et al. 2015). Such assessments are meant to be an iterative learning process, whereby information gaps are identified and conceptual models are developed and updated with new information as it becomes available (Quinlan et al. 2016). A broadly accepted description of the system is the crucial first step in a resilience assessment and sets the stage for future quantitative assessments of the resilience and transformability of the system. Here we present such a description of the UMRS that describes the relevant historical changes and major management concerns for the UMRS, and synthesize our ecological understanding to identify critical controlling variables of the system.

STUDY AREA AND APPROACH

The Upper Mississippi River System is the “commercially navigable portions of the Mississippi River main stem north of Cairo, Illinois” and commercially navigable tributaries, including the entire Illinois River (Water Resources Development Act of 1986, 33 U.S.C. §§ 652). The UMRS comprises approximately 2000 river kilometers and adjacent floodplain lands. The importance of the UMRS as a multiple use natural resource is evident in its congressional recognition as a nationally significant transportation system and a nationally significant river ecosystem. Further, the Upper Mississippi River is highly valued for ecological, economic, recreational, and aesthetic uses and supports economic activities generating nearly $350 billion annually along its corridor (Carlson 1999; U.S. Fish and Wildlife Service 2015).

We followed the Resilience, Adaptation and Transformation Assessment framework (O'Connell et al. 2015) which consists of three primary elements: 1) system description, 2) assessing the system, and 3) adaptive governance and management. Here we focus on the System Description and its implications for the System Assessment. In compiling this description we relied on input from a ‘resilience working group’, partnership workshop, existing reports describing issues of management concern and objectives, and substantial review by representatives of various agencies of earlier drafts of this manuscript. The resilience working group was formed when the project was initiated and is composed of representatives of three federal agencies and each of the UMRS states. We hosted a 3-day workshop with this group as well as other UMRS natural resource managers and scientists in January 2016, which was led by two facilitators with expertise in resilience concepts and applications. At this workshop, participants established a common understanding of resilience and began identifying critical aspects of the system, including: 1) the scale and boundaries of the system to be examined, 2) what is valued by the users of the system, and 3) the drivers, main resource uses, controlling variables and feedbacks. There is a substantial body of reports and publications which contains various descriptions of the UMRS, conceptual models of its structure and function, and management objectives (Lubinski 1993; Theiling et al. 2000; U.S. Army Corps of Engineers 2011). Following the workshop, an extensive review of this literature was conducted to further develop the description of the system. Due to the large network of managers, we presented and sought feedback on our approach at several regional meetings.

THE UPPER MISSISSIPPI RIVER: YESTERDAY AND TODAY

Over the past 200 years, humans have significantly altered the physical and ecological condition of the UMRS (Figure 2). As steamboat traffic grew during the 19^{th} Century, the need for large quantities of wood to fuel steamboats lead to extensive deforestation (Norris 1997). Higher elevation prairies were rapidly converted to agriculture to support growing settlements (Nelson et al. 1994; Turner and Rabalais 2003). The 1850 Swamp Lands Act transferred over 400 km^2 of federally-owned wetlands in the Mississippi River floodplain and an additional 30,000 km^2

throughout the basin (upstream of the Missouri River confluence) to states for conversion into agricultural production (McCorvie and Lant 1993; Hey and Phillippi 1995). Between 1873 and 1891, drainage districts were created that allowed private landowners to organize agricultural improvement efforts, such as dredging and channelization of streams, installation of tile drainage, and construction of levees (McCorvie and Lant 1993).

Growing populations, water infrastructure and changing land use throughout the basin degraded water quality. In 1900, the completion of the Chicago Sanitary and Ship Canal allowed Chicago to discharge significant amounts of untreated sewage and industrial waste into the Illinois River (Karr et al. 1985). The 1972 Clean Water Act reduced the input of these and other point source pollutants to the river; however, the industrialization of agricultural practices and the post-world war II development of the fertilizer industry resulted in large increases in sediment and nutrient loads to the UMRS and Gulf of Mexico having substantial effects on these ecosystems (Turner and Rabalais 2003). Though efforts to improve agricultural land use practices are growing (U.S. Department of Agriculture 2012), the agricultural dominance of the UMRS catchment land use continues to shape the condition of the river today (Turner and Rabalais 2003).

Modifications to improve navigability have profoundly changed the river. Early modifications included clearing snags, construction of wing dams, and blasting of shallow rapids near Des Moines and Rock Island (Dobney 1977; Anfinson 2003). Subsequent work to establish and maintain a progressively deeper navigation channel included construction of two thousand additional wing dams and closing dams, stabilization of nearly 200 miles of river bank with rock, extensive dredging and two locks (Dobney 1977; Anfinson 2003; Fremling 2004). One of these locks and dams, built in 1913 at Keokuk, Iowa included hydroelectric power generation and significantly reduced passage of migratory fishes (Fremling 2004). An upwelling of conservationists who sought to protect remaining but quickly disappearing natural habitat along the river resulted in the establishment of the Upper Mississippi River Wildlife and Fish Refuge in 1924 (Meretsky et al. 2000; Anfinson 2003).

In 1930, Congress authorized the construction of a 2.7 m (9 ft.) navigation channel, requiring construction of 29 locks and dams between Minneapolis, Minnesota and St. Louis, Missouri, and eight on the Illinois River. Lock and dam structures established a minimum water surface elevation for navigation, resulting in inundation of approximately 630 km^2 of floodplain between Minneapolis, MN and Cairo, IL that now exist as large, shallow impoundments (Fremling 2004; De Jager et al. 2013b). Downstream of St. Louis, where locks and dams were not needed, an additional 768 dikes and 224 revetments were constructed between 1930 and 1945 (Dobney 1977). While effective for maintaining a deep channel for navigation, river training structures have reduced channel complexity and reduced the extent of low-velocity habitats (Shields 1995; WEST Consultants 2000). The effect of river training structures on flood stages in the Unimpounded reach of the river remains controversial (Remo et al. 2009; Watson et al. 2013). Even with navigation infrastructure, annual dredging in excess 8 million metric tons per year continues throughout the system to maintain the navigation channel (WEST Consultants 2000; U.S. Army Corps of Engineers 2016).

The Flood Control Acts of 1928 and 1936 authorized floodways, strengthened levees, channel improvements and cost-sharing for structural projects on the Mississippi River downstream of Rock Island, Illinois (Dobney 1977; Myers and White 1993). Levee construction isolated large tracts of floodplain from the river and also contributed to increased flood levels (Remo et al. 2009) and reduced flood storage capacity (WEST Consultants 2000). Subsequent flood-control legislation resulted in channelization of tens of thousands of miles of major tributaries and streams for flood abatement purposes (Brown 1974; Dobney 1977; Schoof 1980).

The cumulative effects of modifications to the basin, floodplain, and river have shaped the modern river's geometry and planform and resulted in many concerns regarding the long term condition of the river. Today, the UMRS is commonly described as four river-floodplain reaches based on vegetation and floodplain connectivity: the Upper Impounded reach, the Lower Impounded reach, the Unimpounded reach, and the Illinois River reach (Figure 1; Table 1; (Peck and Smart 1986; Lubinski 1993; U.S. Army Corps of Engineers 2011). Land use changes have increased nutrient inputs that contribute to eutrophic conditions frequently observed in the river (Houser and Richardson 2010). Land use changes have also increased sediment loads (Knox 2001) that have reduced water clarity, and, in combination with navigation infrastructure, result in high rates of sedimentation, loss of depth, and loss of spatial extent of low-velocity areas, such as backwaters and side channels (Bhowmik and Adams 1989; Bhowmik and Demissie 1989; WEST Consultants 2000). Large, shallow impoundments suffer from increased wind-induced turbidity and island erosion (WEST Consultants 2000). Loss of floodplain connectivity due to levees has eliminated the exchange of nutrients, organisms and organic matter between river and floodplain environments that support biological diversity and productivity (Sparks 1995). The operation of the locks and dams have eliminated the seasonal low water levels that occurred prior to impoundment (Theiling and Nestler 2010), and likely have facilitated the invasion of Reed canarygrass (*Phalaris arundinacea*) through the negative impacts of increased water elevations on forest recruitment (Thomsen et al. 2012). Levees, navigation infrastructure, extensive channel modifications of streams and rivers throughout the basin, and basin-wide land use changes have further modified flow regimes through increased discharge (Raymond et al. 2008; Schilling et al. 2010) and water level variability (Sparks et al. 1998; Raymond et al. 2008; Schilling et al. 2010; Watson et al. 2013). For subsequent purposes, we classify these historical changes as external drivers that influence system dynamics, yet are ultimately external to, or managed at scales larger than, the system as we have defined it. We also acknowledge that these external drivers will remain within the system for the foreseeable future and influence the adaptive capacity of the system.

HOW DOES THE UPPER MISSISSIPPI RIVER SYSTEM FUNCTION?

Critical to the structure and function of large floodplain rivers are fluxes of water and materials and movement of biota among the diverse aquatic and terrestrial areas that comprise the river and its floodplain (Ward et al. 1999; Opperman et al. 2010). These interactions occur across the diverse river-floodplain landscape and underpin high rates of biological diversity and productivity (Hein et al. 2003). To clearly identify the controlling variables within the UMRS ecosystem, we conceptualize the river as being composed of three interacting subsystems: lotic channels, lentic off-channel aquatic areas, and floodplains (Figure 3). For example, lotic channels affect lentic off channel areas by the rate of nutrient and sediment delivery. Lentic off-channel areas are hot-spots of nutrient processing and biotic production. Some of that biological production is subsequently returned to lotic environments as organic matter, phytoplankton, zooplankton, and invertebrates, which provide forage resources for organisms of higher trophic levels (Polis et al. 1997). Hydrologic connectivity sufficient to permit fish movement among these areas of the river and floodplain at appropriate times of the year is fundamental to support diverse fish communities that have different seasonal and ontogenetic habitat needs (Galat and

Zweimuller 2001). Complex mosaics of habitat in floodplain river environments further support terrestrial biota, including birds, mammals, reptiles, amphibians, and invertebrates (Robinson et al. 2002).

These three subsystems are distinguished by the combination of dominant controlling variables that structure ecosystem properties within each subsystem (Figs 4 – 6). The lotic model describes those portions of the system that are dominated by substantial water current--primarily main and side channels. The lentic off-channel model describes backwater and floodplain lakes and wetlands, and the expansive impounded areas immediately upstream of lock and dams where factors such as depth, velocity, fetch, and water clarity are important drivers of local conditions. We consider floodplains to include the areas that experiences intermittent inundation. In these areas, the extent and duration of inundation is a primary driver of local conditions (e.g.,(De Jager et al. 2015b). Much of the historic floodplain has been disconnected from the river by levee construction and this disconnection from the river is a fundamental change in the structure and function of those areas; however, we focus here on ecological relationships in floodplains that remain actively connected to the river.

The following sub-system conceptual models are not meant to be a comprehensive description of the river system, but rather a simplified representation of each sub-system intended to highlight the key controlling variables that structure the existing UMRS ecosystem. In the process of developing these conceptual models, we synthesized output from a UMRS resilience workshop where a group of natural resource managers and scientists identified valued ecosystem services throughout the system. We then identified the Major Resources required to support those valued ecosystem uses or services within each sub-system (Figure 4). Therefore, *Major Resources* directly support popular uses of, and ecosystem services provided by, the river ecosystem, and include water quality, native fish communities, native mussel communities, aquatic vegetation, waterfowl, floodplain vegetation, and avian communities. *Controlling Variables* are the dominant factors believed to affect major resources and can also be influenced by management agencies. As previously described, *External Drivers* influence controlling variables, but are generally controlled at scales beyond the control of natural management agencies.

Lotic channels

Water quality

Water quality is an important factor determining habitat suitability for riverine biota (see examples in sections below) and supporting a diversity of recreational and commercial uses (Figs. 4 & 5). Two components of water quality, total suspended solids and nutrient concentrations are considered Controlling Variables in the lotic channels because of their extensive effects on river ecosystems (e.g.(Hilton et al. 2006; Houser and Richardson 2010; Kjelland et al. 2015). High concentrations of TSS and nutrients in the lotic areas of the river result in high inputs to lentic, off-channel areas (see below), reduced aesthetic value, and increased water treatment costs for drinking water and industrial uses.

Mussels

Native freshwater mussels likely play an important role in the functioning of large river ecosystems through effects on nutrient and energy cycling that results from their substantial rates of water filtration and processing (Newton et al. 2011) However, as a group, mussels have experienced a substantial, long term decline due to historical commercial exploitation and episodes of degraded water quality (Tucker and Theiling 1999; Anthony and Downing 2001). Mussels are strongly affected by local hydrogeomorphic conditions, resulting in 'patchy' spatial patterns (Ries et al. 2016). Mussels require substrate stability during high flow conditions and minimum water velocities to transport oxygen, food, and waste materials during low flow conditions (Morales et al. 2006; Steuer et al. 2008; Zigler et al. 2008). Mussel recruitment relies on host fish species for dispersal during the veliger life stage, thus factors that impact fish distribution and abundance affect mussel communities. For example, lock and dam 19 is a barrier to fish migration and has prevented migratory fishes such as skipjack herring (*Alosa chrysochloris*), a host fish for the ebony shell (*Fusconaia ebena*), from accessing a large portion of the river (Kelner and Sietman 2000). Mussels are also affected by water quality. Historic industrial and domestic pollution led to mussel declines and extirpation, for example, in parts of the Illinois River (Starrett 1971), but partial recovery of mussel populations followed reductions in point source pollution (Sietman et al. 2001). The invasive zebra mussel (*Dreissena polymorpha*) has established throughout the UMRS (Cope et al. 1997) and likely influence native mussel communities (Tucker et al. 1993) and water quality (James et al. 2000).

Fish

Fish populations of the UMRS have diverse effects on the ecosystem through predation, bioturbation and their requisite role in the recruitment and dispersal of native mussels. UMRS fishes also support commercial and recreational fisheries, and are an integral part of the social culture of the UMRS (e.g.(Schramm and Ickes 2016). Fish use of lotic channels varies depending on species' life history requirements. Some species use channels as a migratory route to access seasonal habitats, other species reside in channels specifically for spawning and/or foraging, and rheophilic species tend to be year-round residents of the main channel (Dettmers et al. 2001a). To accommodate the diverse life history needs of persistent and seasonal residents, as well as opportunistic limnophilic species, heterogeneity of depth and velocity within the riverine environment is essential (Galat and Zweimuller 2001).

This heterogeneity promotes diverse food webs that provide the range of forage resources required for a diverse fish community. Riverine phytoplankton and zooplankton are small, rapidly reproducing (Pace et al. 1992; Reynolds 1994; Reynolds and Descy 1996), and their community structure is influenced by TSS and connectivity with lentic areas (Wahl et al. 2008; Havel et al. 2009; Burdis and Hoxmeier 2011; Ochs et al. 2013; Manier 2014; Decker et al. 2015). Current velocity and substrate type within the channel influence the distribution of benthic invertebrates (Fremling 1960; Seagle et al. 1982; Anderson and Day 1986; Dettmers et al. 2001b), while connectivity with adjacent lentic areas provide important sources of invertebrate drift (Eckblad et al. 1984; Sheaffer and Nickum 1986b). Hydraulic traps within the river bedform (i.e., sand dunes) support the retention of macroinvertebrate drift (Gutreuter et al. 2006), and provide low-velocity refuge and energetic savings for fishes feeding on drift in the main channel (Lehtinen et al. 1997; Guensch et al. 2001; Wildhaber et al. 2003; Gaeuman and Jacobson 2007). Similarly, drift-feeding fishes have been observed to use areas of reduced current velocity below sandbars, likely allowing them to maintain their position in a lower velocity environment while feeding on drift (Rosen et al. 1982).

Connectivity of lotic channels with lentic areas and floodplains benefit fish communities in other ways as well. Within the lotic channel, longitudinal connectivity support access to spawning habitat, and dispersal of buoyant eggs and drifting larvae to nursery habitats (Holland and Sylvester 1983; Holland 1986), yet can be fragmented by high-head dams (Wilcox et al. 2004). Connectivity to off-channel areas and inundated floodplains is important for access to nursery environments (King et al. 2003; Schramm and Eggleton 2006; Schiemer and Hein 2008). Though many fluvial specialists and dependents, such as shovelnose sturgeon (*Scaphirhynchus platorynchus*) and paddlefish (*Polyodon spathula*), remain in the main channel throughout winter (Lubinski 1984; Sheehan et al. 1994; Quist et al. 1999; Zigler et al. 2003; Hurley et al. 2004), seasonal residents, such as freshwater drum (*Aplodinotus grunniens*), may leave channel environments to seek more favorable overwintering conditions elsewhere (Bodensteiner and Lewis 1992). During high flow events, lotic fishes commonly seek refuge from high velocities (Dettmers et al. 2001a; Hurley et al. 2004; Schwartz and Herricks 2005; Koch et al. 2012).

Invasive species, including silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*Hypophthalmichthys nobilis*), have established in the Illinois River (Sass et al. 2010), Middle Mississippi River (Williamson and Garvey 2005), and the lower impounded reach of the UMR over the past 20 years (Chick and Pegg 2001). While the mechanisms behind their establishment are not known conclusively, they have impacted native fish communities and food resources (Irons et al. 2007; Sass et al. 2014; Solomon et al. 2016).

Lentic off-channel areas (Figure 4)

Water quality

In lentic areas, water quality directly influences aquatic vegetation, fish, and mussels, and supports aesthetic and recreational uses (Figs. 4 and 6). As in the lotic subsystem, TSS and nutrients are considered controlling variables because of the effects on the structure and function of off-channel lotic areas. TSS is a primary determinant of light environment and substantially affects the distribution of aquatic vegetation (see next section). High nutrient concentrations in lentic areas are associated with thick mats of free-floating plants and filamentous algae (e.g., duckweed) which can prevent light from reaching the water and is associated with reduced dissolved oxygen concentrations (Houser et al. 2013; Giblin et al. 2014). Dissolved oxygen and temperature are critical aspects of water quality as a Major Resource. They are not listed as key controlling variables because they are strong functions of connectivity, velocity, aquatic vegetation (all of which are included in the model) and are functionally intermediate drivers of habitat suitability that are responding to the controlling variables contained in the model.

Connectivity with lotic channels affects water quality by determining the rate of delivery of nutrients and sediment (Richardson et al. 2004; Strauss et al. 2011; De Jager and Houser 2012; Houser et al. 2013; Houser 2016). For example, less-connected backwaters have lower velocity, longer water residence time, lower nitrogen concentrations, higher temperatures and lower dissolved oxygen concentrations than main channel environments (Sheaffer and Nickum 1986a; Bodensteiner and Lewis 1992; Knights et al. 1995). Less connected backwaters, especially those with extensive vegetation, often have lower TSS concentrations (Knowlton and Jones 2003; Pongruktham and Ochs 2015). However, shallow backwaters with scarce vegetation can exhibit high turbidity due to sediment re-suspension similar to impounded areas (Sparks et al. 1990; Houser 2016). Depth affects water quality in backwater areas because deep backwater lakes may stratify, providing depth-dependent contrasts in velocity, temperature, and dissolved oxygen affecting habitat suitability during summer and winter (Gent et al. 1995; Johnson et al. 1998).

Aquatic vegetation

During the growing season, aquatic vegetation provides structural cover for fish and invertebrates, and forage resources for waterfowl which are especially critical during spring and fall migration. Light availability is a critical factor in the distribution and abundance of submersed aquatic vegetation (Kimber et al. 1995; Korschgen et al. 1997; Kreiling et al. 2007; Moore et al. 2010). Light reaching the substrate and average water column light condition is determined by the combined effects of water depth and TSS (Kirk 1994). Large wind fetch, common to impounded areas of the upper impounded reach, produces high wave energy that re-suspends sediments, increases TSS, and reduces light penetration (Owens and Crumpton 1995; Koch 2001). The feedbacks and interactions between vegetation abundance and turbidity due to sediment re-suspension observed in shallow lakes (e.g.(Scheffer and van Nes 2007) likely occur in the large, shallow impounded areas and backwaters of the UMRS (Sparks et al. 1990). Reduced TSS has allowed temporary macrophyte establishment in otherwise light-limited environments, while increased TSS and re-suspension have shifted clear and vegetated areas to turbid and unvegetated areas (Sparks et al. 1990; Fischer and Claflin 1995; Theiling et al. 1996). There is also a possible interaction between depth and turbidity; as ongoing sedimentation reduces depth in impounded and backwater areas, which can amplify sediment re-suspension by wave energy.

Aquatic vegetation species have varying velocity preferences that result in differences in community structure in fast and slow current velocity environments (Peck and Smart 1986). High flow velocity and TSS during flood events can significantly affect the abundance and distribution of aquatic vegetation (Spink and Rogers 1996). Slow current velocity (<0.01 m/s) enhances growth of many species of aquatic vegetation (Madsen et al. 2001). Emergent vegetation provides food, cover, and nesting material to waterfowl and fish, and is generally restricted to shallow depths (generally <1 m) and low water velocities (Peck and Smart 1986). Duckweed and filamentous algae, which favor low velocity, shallow, nutrient-rich conditions that often peak mid-summer in isolated backwaters (Houser et al. 2013; Giblin et al. 2014), can adversely affect both the aesthetics and the functioning of the ecosystem (reduced light availability and dissolved oxygen concentrations) when abundant.

Higher minimum water levels and increased water level fluctuations during the growing season due to dam operations can inhibit establishment of emergent vegetation, and moist-soil plants (Sparks et al. 1998). Management efforts to reduce short-term water-level fluctuations and minimum water elevations through the use of water-level drawdowns have been associated with increases in vegetation in parts of the river (Wlosinski et al. 2000), though vegetation response appears to vary with the composition in the seed bank (Kenow and Lyon 2009; Schorg 2014).

Mussels

Lentic mussel communities exhibit greater diversity and abundance in areas well-connected with lotic channels than in more isolated backwaters (Tucker et al. 1996; Zigler et al. 2008), likely due to oxygen requirements and transport of food and waste material, but also may be influenced by sedimentation and pollutants in less connected backwaters. Adult and juvenile mussels may respond differently to the degree of connectivity between lentic and lotic areas, with some backwaters potentially serving as population sources and others as sinks (Reis et al. 2016).

Fish

Off-channel aquatic areas commonly provide fish spawning and nursery habitats (Holland 1986; Sheaffer and Nickum 1986a), diverse foraging resources, and refugia when low temperature (i.e., during winter) or high velocity conditions (i.e., during floods) exist in the main channel. Fishes use lentic areas for a variety of purposes, depending on their life history requirements. In late spring and summer, backwater habitats often have increased residence time, low velocities, shallow depths, food resources, and warm temperatures that are important for growth and development of larval fish (Sheaffer and Nickum 1986a; Nannini et al. 2012). Backwaters generally support diverse phytoplankton, zooplankton, and macroinvertebrate communities which serve as important food sources for larval and adult fishes (Eckblad et al. 1984; Sheaffer and Nickum 1986b; Wahl et al. 2008; Burdis and Hoxmeier 2011; Ochs et al. 2013). Submersed vegetation and other forms of structural complexity (such as coarse woody debris) provide protection from predation (Dewey et al. 1997), and promote growth (Richardson et al. 1998) and abundance of certain young-of-year species (DeLain and Popp 2014). On the other hand, foraging of sight feeding fish and reproductive success in backwaters with high suspended sediment concentrations may be limited (Kjelland et al. 2015).

During winter, as temperatures drop to 5-10^0 C, many species seek out low velocity backwater areas that allow minimal energy expenditure and provide protection from harsh conditions (Sheehan et al. 1994). Deep backwaters (depth > 1.2m) with velocity near zero are characterized as centrarchid overwintering habitat as they generally maintain adequate dissolved oxygen and temperature (Palesh and Anderson 1990; Bodensteiner and Lewis 1992; Gent et al. 1995; Knights et al. 1995; Raibley et al. 1997). Conversely, during periods of low discharge in the summer, lentic fishes seek foraging opportunities in lotic channels (Gutreuter et al. 2010).

The invasive common carp, found throughout the UMRS, are well known to uproot aquatic vegetation and increase turbidity while foraging (Lubinski et al. 1986). At high biomass levels, common carp have exhibited negative impacts on both aquatic vegetation and waterfowl abundance in shallow lakes (Bajer et al. 2009) and likely have impacts on the native fish community.

Waterfowl

The Upper Mississippi River is an important migratory corridor for waterfowl, which are highly valued for hunting and bird-watching activities. Waterfowl rely on lentic off-channel areas for feeding and resting during spring and fall migrations. Diving ducks are associated with expansive open areas, common to impounded areas, that support aquatic vegetation (Korschgen 1989). In the fall, diving ducks feed on submersed aquatic plants, including American wildcelery (*Vallisneria americana*) (Korschgen et al. 1988), as well as invertebrates, including fingernail clams (Thompson 1973). Dabbling ducks commonly forage in shallow wetlands, backwaters and inundated floodplains that support moist soil plants and invertebrates in spring and fall (Reid et al. 1989; Stafford et al. 2007). Areas where aquatic plants are absent or in low density have limited foraging value for waterfowl (Vonbank et al. 2016), however, dabbling ducks have responded well to restoration of aquatic vegetation (Dugger and Feddersen 2009; Hagy et al. 2016). Tundra swans (*Cygnus columbianus*) commonly use the UMR during fall migration to forage on emergent and submergent plants (Thorson et al. 2002; Baldassarre 2014). Emergent vegetation and rooted floating aquatic vegetation also provide cover and food resources for locally nesting waterfowl (DeHaan 1999).

Floodplains

Floodplain Vegetation

Floodplain vegetation includes a range of communities, including emergent marshes, wet meadows, grasslands, and floodplain forests. Flood inundation plays a fundamental role in the distribution of UMRS floodplain plant communities (De Jager et al. 2015a), forest species distributions (De Jager et al. 2012), and forest age structure (De Jager 2012). Flood inundation is the manifestation of spatial and temporal variability in water and land surface elevation. Land surface elevation is largely determined by the net effects of erosion and sedimentation processes (Hodges 1997; Sluis and Tandarich 2004), but likely also impacted by historic dredge material placement in the active floodplain (WEST Consultants 2000). Water surface elevation is controlled by the navigation infrastructure along the UMRS as well as watershed characteristics that impact runoff. For a given water surface elevation, areas of lower land surface elevation experience more frequent inundation, greater flooding depths and longer flood durations. These hydrological variables directly affect vegetation by influencing the survival of different plant species and age classes (Hosner and Minckler 1963; Hodges 1997). For example, spatial variability in flood duration along the UMR floodplain creates a spatial mosaic of plant communities, where marsh communities are typically found in areas that flood more than 125 days per growing season and floodplain forests are rarely found in areas the flood for longer than 100 days per growing season (De Jager et al. 2015a). Critical thresholds in the distribution of different forest tree species and age classes may also exist along the UMR floodplain. For example, a diverse array of tree species with a wide-range of adaptations to inundation occur in areas that flood for less than 60 days per growing season, while only the most highly flood tolerant species occur in areas that flood for longer durations (De Jager et al. 2012). Furthermore, smaller tree seedlings and saplings are more easily overtopped during flooded conditions, and for this reason, the areas of more frequent and longer inundation durations tend to be dominated by older cohorts and lack evidence of understory regeneration (De Jager 2012).

Patterns of flood inundation also directly impact the texture and nutrient availability of local floodplain soils (Hodges 1997) which can further influence forest structure and composition (Hosner and Minckler 1963). For example, following the large flood of 1993, high rates of sediment deposition were observed (Yin 1998) which may have allowed for species such as willow and cottonwood that are known to establish on newly deposited sediments (Hosner and Minckler 1963) to regenerate. Long-term patterns of flood inundation can also influence the deposition of fine textured sediments and the spatial pattern of organic matter in the UMR floodplain, characteristics that not only impact forest composition, but also alter nutrient cycling in ways that may impact river water quality (De Jager et al. 2012 and see below).

Invasive species also directly impact floodplain vegetation. In the upper reaches of the river, reed canarygrass invades forest canopy gaps and suppresses the growth of tree seedlings (Thomsen et al. 2012); a number of possible interactions and positive feedbacks may be accelerating its spread. Large magnitude flood events and high rates of herbivory on tree seedlings by white-tailed deer can further shift the balance toward reed canarygrass by causing high rates of tree mortality during early succession (De Jager et al. 2013a). Once established, reed canarygrass may alter soil nitrogen cycling in ways that further promote its growth and alter water quality. In a recent study, nitrogen availability was at least two times greater in patches of reed canarygrass as compared to mature floodplain forests (Swanson In Review). Such increases in soil nitrogen availability likely promote continued dominance by reed canarygrass as it is known to thrive in high nitrogen environments (Green and Galatowitsch 2001). Several additional invasive species also impact the vegetation of the UMRS but are less-well studied (e.g., Japanese hops, Japanese knotweed, cucumber vine, Black locust, Guyon et al. 2012).

Water quality

Exchange of water between a river and its floodplain transports sediments, nutrients and organic matter (Tabacchi et al. 1998; Tockner et al. 1999; Noe and Hupp 2009). For example, flood pulses deposit fine particulate organic matter on floodplains and return dissolved organic carbon to the river (Grubaugh and Anderson 1989; Junk et al. 1989; Tockner et al. 1999). Floodplains are also known for relatively high potential for denitrification, a microbial process by which nitrogen can be completely removed from the system (Pinay et al. 2000). Hence, floodplains play a potentially large role in the water quality of rivers. In the UMRS, the flood regime creates spatial patterns in floodplain soils, with higher amounts of organic matter in low-lying areas and sandier soils in higher elevation areas (De Jager et al. 2012). These spatial differences may support differences in denitrification potential as soil texture and organic matter are often strong predictors of denitrification rates in floodplains (Pinay et al. 2000). However, nutrient availability and cycling rates in the UMR are heavily influenced by temporal variation in water levels and associated anoxic conditions (De Jager et al. 2015b; Kreiling et al. 2015), suggesting that changes in water levels could influence nutrient cycling (Cavanaugh et al. 2006).

Avian community

The structure and composition of floodplain vegetation directly affects the avian community. During spring migration, trees within UMR floodplain forests commonly leaf out and flower early relative to upland areas, providing regionally important nesting and foraging habitat for migrating birds (Kirsch et al. 2013). Tree species-specific differences in leaf-out, flowering, and associated arthropod abundances create strong potential for variation in bird-tree species associations. Bird species that breed locally in the UMR tend to prefer the most abundant tree species, silver maple (Kirsch and Wellik In Review). In contrast, transient migrant species such tend to prefer hackberry (*Celtis occidentalis*) and oaks (*Quercus spp*.), especially in years with delayed leaf-out. Mature forests that have greater tree species richness and structural diversity as compared to young forests or more monotypic mature stands provide large dead snags that are critically important nesting habitats (Knutson et al. 2005). Hence, the lack of forest regeneration in some areas and shift toward more monotypic stands may impact the avian communities that utilize the floodplain. Bird communities are also impacted by flood inundation as colonial nesting birds often utilize mature trees that are close to shallow aquatic foraging habitat (Custer et al. 2004). Furthermore, shorebirds are sensitive to flood inundation because they rely on seasonally inundated floodplains for foraging habitat during Spring and Fall migration, particularly shallow water with sparse vegetation that promotes invertebrate production (Smith et al. 2012; Twedt 2013).

TOWARDS A RESILIENCE ASSESSMENT

Conceptualizing the four UMRS floodplain reaches as simplified mosaics of three subsystems makes clear the substantial differences in the abundance and distribution of, and connections among subsystems across the four floodplain reaches (Table 1; Figure 7). These contrasts in geomorphology and hydrologic connectivity among reaches can be considered in the context of principles that have been proposed for enhancing the resilience of ecosystem services (Biggs et al. 2012). The first principle emphasizes the importance of response diversity and functional redundancy; the second principle describes how sufficient connectivity enables a system to better recover after a disturbance, but cautions that high levels of connectivity can allow a disturbance to spread throughout the system. Ward et al. (1999) suggest that that intermediate connectivity of river floodplains is desirable. Sparks et al. (1998) state that much of the UMRS backwaters, especially in the Upper Impounded reach were historically less connected and the natural flow and disturbance regimes resulted in less transport of sediment to these areas. Thus, the importance of hydrologic connectivity across the floodplain is generally accepted, but the specifics of how connectivity throughout the UMRS should be managed remains poorly understood.

The Upper Impounded reach has abundant and diverse lentic and floodplain areas likely providing hydro-geomorphic functional redundancy and response diversity. This reach also has relatively high connectivity among off-channel aquatic areas and between those areas and the main channel. This connectivity provides motile biota with a broad range of conditions in controlling variables such as water velocity, depth, and water clarity (TSS), increasing the probability that any given species can find suitable habitat despite wide seasonal fluctuations in discharge and temperature. Lentic-off channel areas are much less abundant in the Lower Impounded reach and nearly absent in the Open River reach where they are generally found only in rare, disconnected floodplain lakes and side channels disconnected during periods of low flow. In these two reaches the floodplain is largely disconnected from the river by an extensive levee system. Within the Illinois River reach, off-channel lentic areas are still found, but they are often substantially degraded by sedimentation and high turbidity and disconnected from the channel. Future research could address the hypothesis that the reduced abundance and diversity of off-channel areas and floodplain connectivity in these lower three reaches has affected the resilience of these areas and in some cases, potentially shifted the river reaches to a new, less-desirable regime.

Understanding and managing the slow variables critical in establishing the underlying structure of the ecosystem is also an important principle for enhancing resilience (Biggs et al. 2012). A number of key slow variables are identified in the conceptual models presented here, such as the spatial and temporal patterns in flood inundation of the floodplain. Research has identified thresholds of inundation duration on floodplain plant communities (De Jager et al. 2012) that have informed management decisions, yet thresholds of other slow variables remain poorly understood or unknown. For example, the ongoing loss of depth in off-channel, lentic aquatic areas has long been, and remains, a primary concern of river managers and users (UMRBC 1982; U.S. Army Corps of Engineers 2011). Whether thresholds in depth exist within these off-channel areas where critical ecological functions required for habitat suitability of Major Resources change rapidly is something that needs to be better understood to evaluate the current resilience of the UMRS. Further, the deposition of coarse grained sediment can form deltas in lentic areas and natural levees on floodplains, which is colonized by vegetation, and becomes a permanent part of the riverscape. This slow process has not be studied extensively to evaluate its magnitude, trajectory, and ecological consequences. Other candidate important slow variables from among the key components identified in our models include: various metrics of connectivity among aquatic areas and between the broader floodplain and those areas; cumulative sediment and nutrient inputs; and distribution, abundance and community composition of aquatic and floodplain vegetation, and long-lived fish species. At the broadest scales, questions remain regarding whether there exists thresholds in the response of riverine biota and ecosystem processes to the overall abundance and distribution of the three major subsystems.

Thus, the four floodplain reaches of the UMRS span gradients in aquatic and floodplain area diversity (De Jager and Rohweder 2012), and hydrologic connectivity (among aquatic areas and between aquatic areas and the floodplain) that may influence the ecological resilience of these reaches. As we proceed in assessing the ecological resilience of the system, we seek to develop a better understanding of the extent to which the composition and connectivity of the major sub-systems within these floodplains reaches interacts with key slow variables to affect the geomorphology, hydrology and biogeochemical processes that dictate ecosystem responses to disturbances, shapes the distribution and abundance biological communities, and contributes to the overall resilience of the UMRS. Relying upon our conceptual understanding of the sub-systems, we will also quantify trends in controlling variables and evaluate relationships between controlling variables and major resources to identify thresholds and feedbacks. Operationalizing resilience concepts provides an opportunity to test our understanding, add information to our conceptual models, and ultimately, identify management strategies that influence the coping capacity of the system.

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Table 1. Summary of the modern characteristics of the four Floodplain Reaches

Floodplain Reach	Main channel	Floodplain lakes and backwater lakes	Impounded areas	Floodplain
Upper Impounded Reach	Maintained as deep; intermittent fragmentation by locks and dams	Permanent inundation of floodplain lakes by locks and dams resulted in abundant backwater lakes; abundant aquatic vegetation	Permanent inundation of low elevation floodplain by locks and dams resulted in large, shallow impounded areas upstream of each lock and dam	Largely publicly-owned wildlife refuge; seasonally inundated; water level stabilized and raised by locks and dams
Lower Impounded Reach	Maintained as deep; intermittent fragmentation by locks and dams	Few backwater or floodplain lakes; scarce aquatic vegetation	Relatively small portion of pools, except Pool 19	Disconnected by levees; largely privately owned and used for agriculture.
Unimpounded Reach	Maintained as deep and fast	Very few backwater or floodplain lakes; scarce aquatic vegetation	None	Disconnected by levees; largely privately owned and used for agriculture.
Illinois River Reach	Maintained as deep; intermittent fragmentation by locks and dams	Abundant backwater lakes degraded by re-suspension of fine sediments; scarce aquatic vegetation	Relatively small portion of pools	Disconnected by levees; largely privately owned and used for agriculture.

Figure captions.

Figure 1. The Upper Mississippi River basin, along with navigation dams and floodplain reaches of the Upper Mississippi River System. Floodplain reaches are color coded and sub-reaches are noted with text, primarily based on the presence of lock and dams.

Figure 2. A timeline of historic changes to the Upper Mississippi River and its basin that have influenced the physical and ecological characteristics of the system.

Figure 3. The Upper Mississippi River can be decomposed into three subsystems: lotic channels, lentic backwater lakes and impounded areas, and floodplains. Connectivity and exchange between subsystems is critical to the structure and function of large floodplain rivers.

Figure 4. A compilation of stakeholder uses and ecosystem services provided by the Upper Mississippi River and the major ecological resources, identified through workshop discussions, program reports, and management plans, which contribute to those uses and services.

Figure 5. A conceptual model of the controlling variables that influence major resources in the lotic channels of the Upper Mississippi River.

Figure 6. A conceptual model of the controlling variables that influence major resources in the lentic backwater lakes and impounded areas of the Upper Mississippi River.

Figure 7. A conceptual model of the controlling variables that influence major resources in the floodplains of the Upper Mississippi River.

Figure 8. An example of the mosaic lotic channels, lentic areas, and floodplains for segments of the river that represent the four floodplain reaches. The orange hashed areas represent floodplains disconnected from the main channel by levees.

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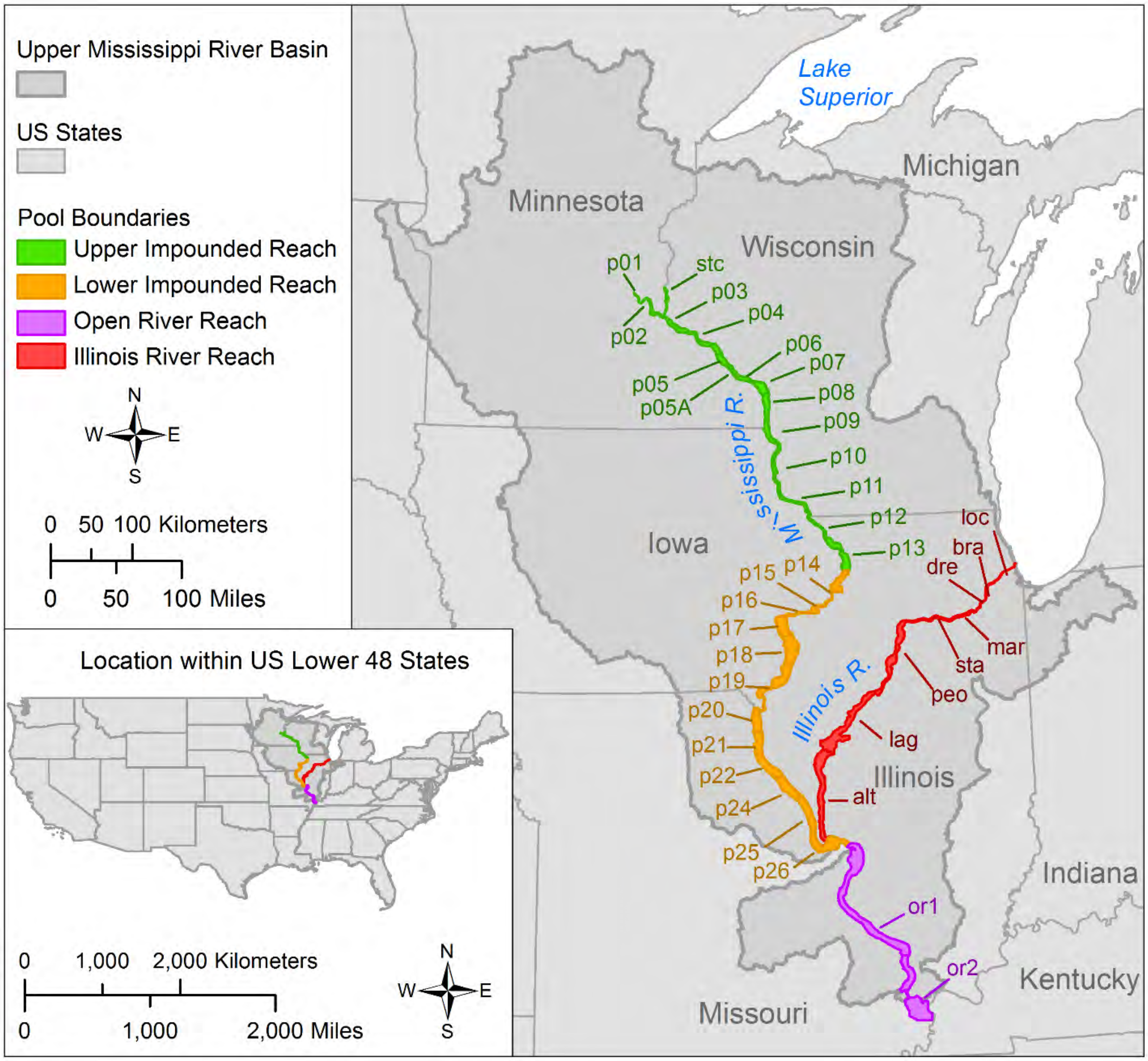

1095 Figure 1.

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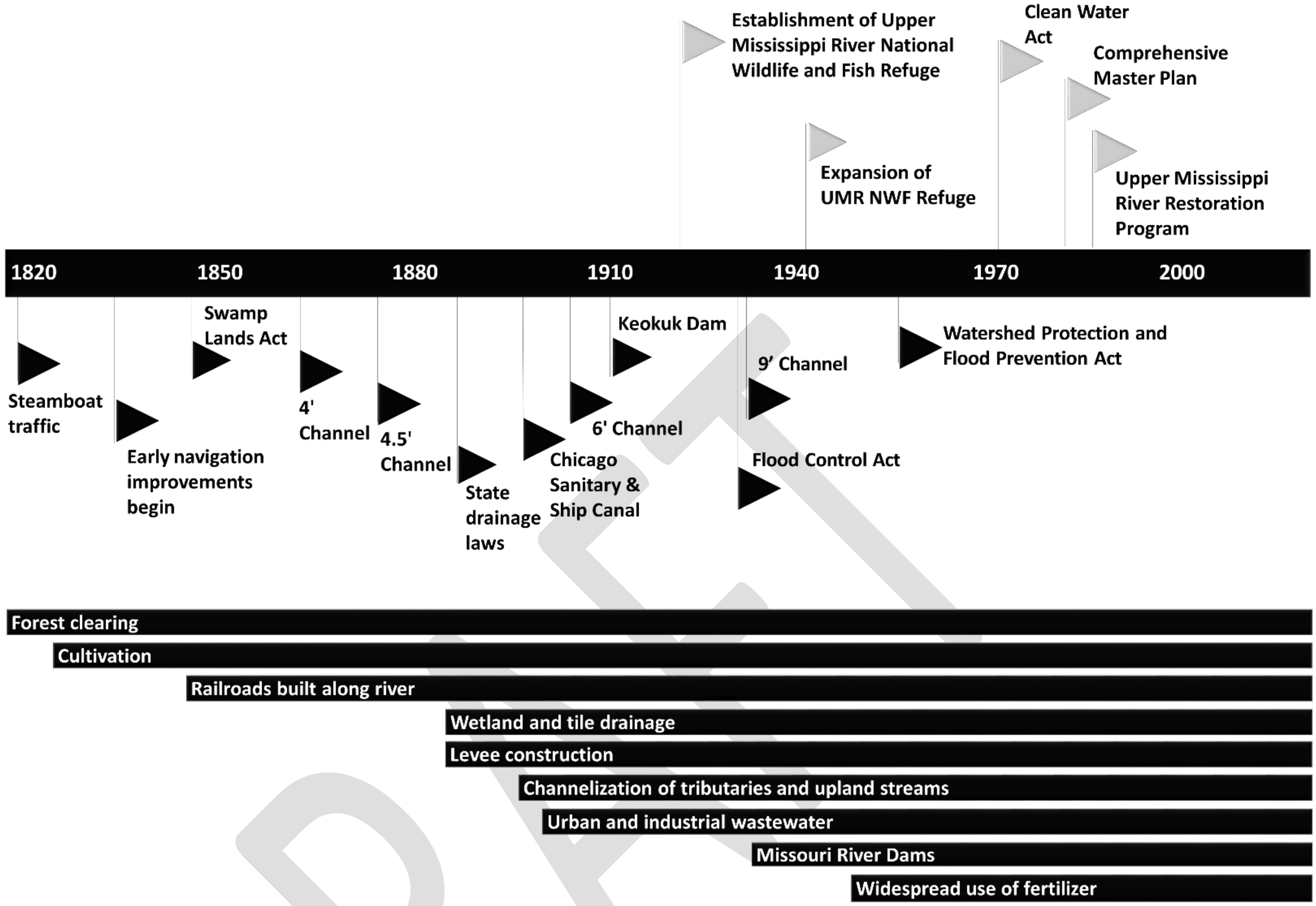

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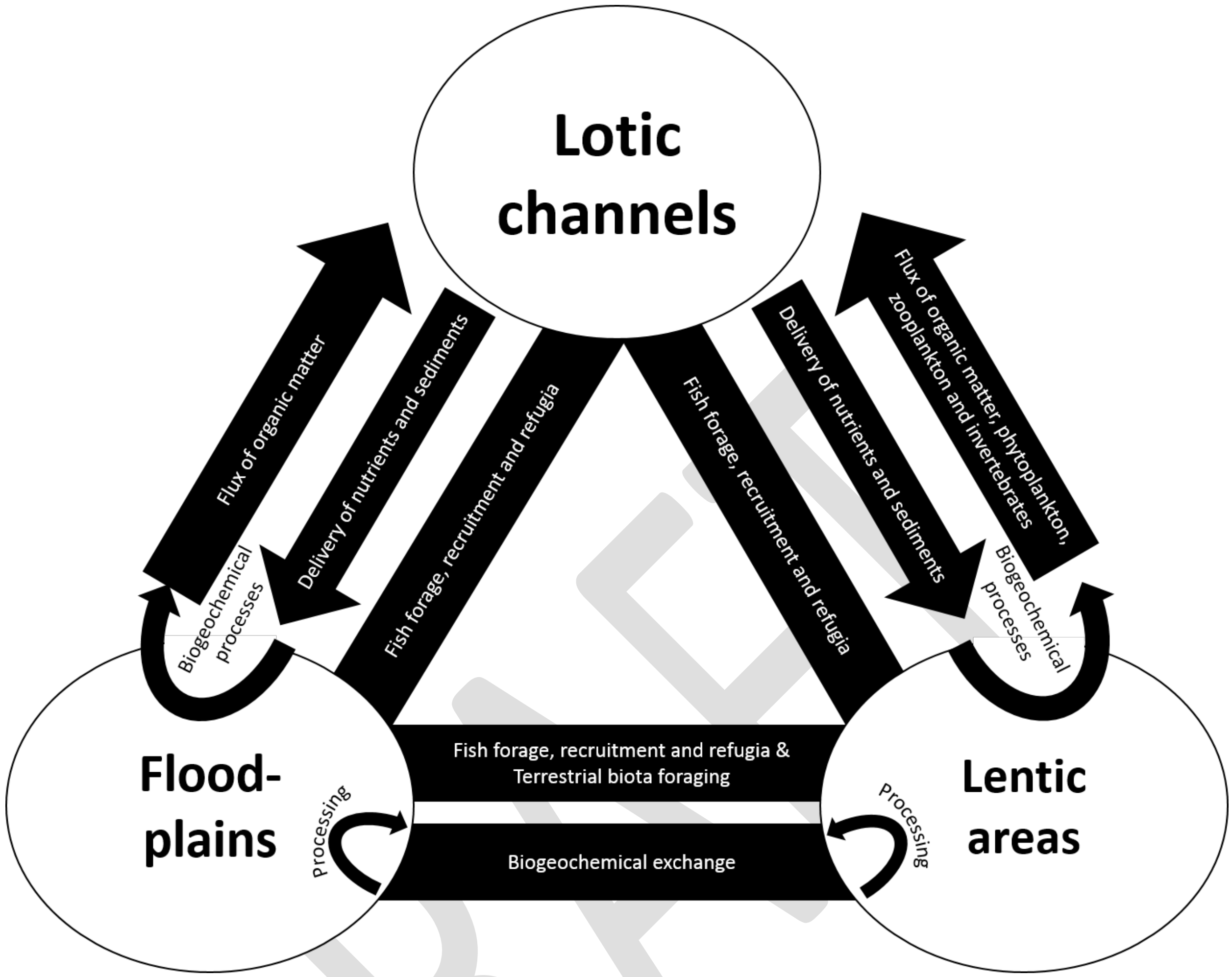

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1100 Figure 3.

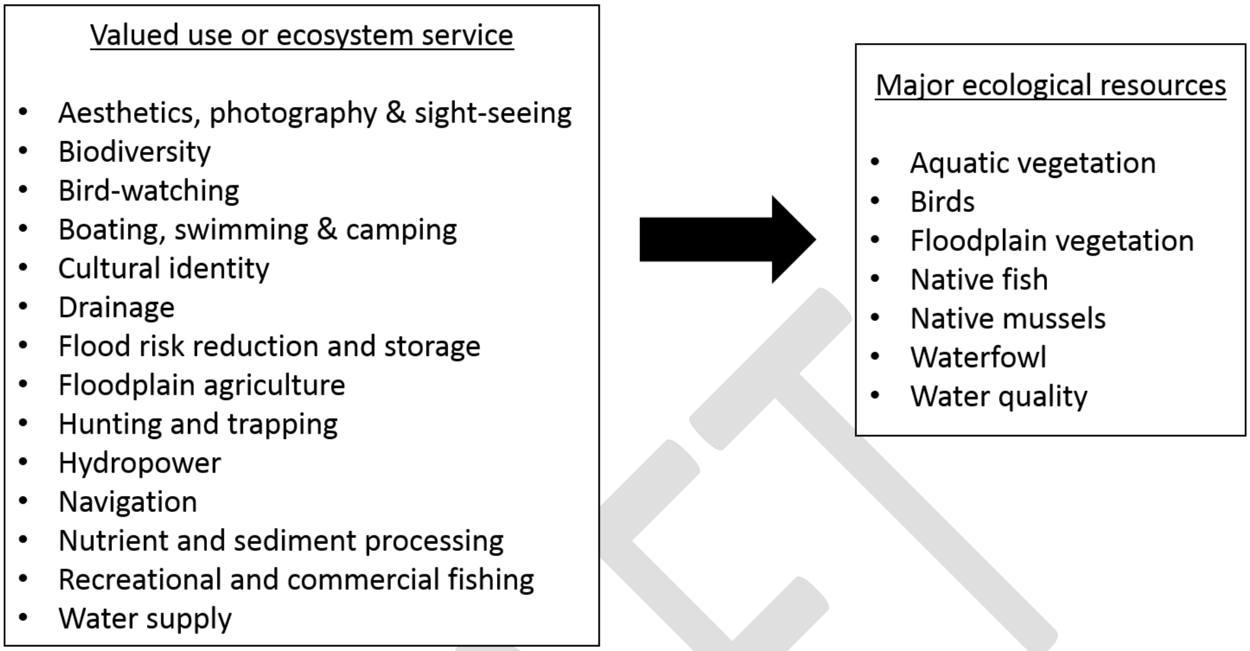

Valued use or ecosystem service
Aesthetics, photography & sight-seeing
Biodiversity
Bird-watching
Boating, swimming & camping
Cultural identity
Drainage
Flood risk reduction and storage
Floodplain agriculture
Hunting and trapping
Hydropower
Navigation
Nutrient and sediment processing
Recreational and commercial fishing
Water supply
Major ecological resources
Aquatic vegetation
Birds
Floodplain vegetation
Native fish
Native mussels
Waterfowl
Water quality

Figure 4.

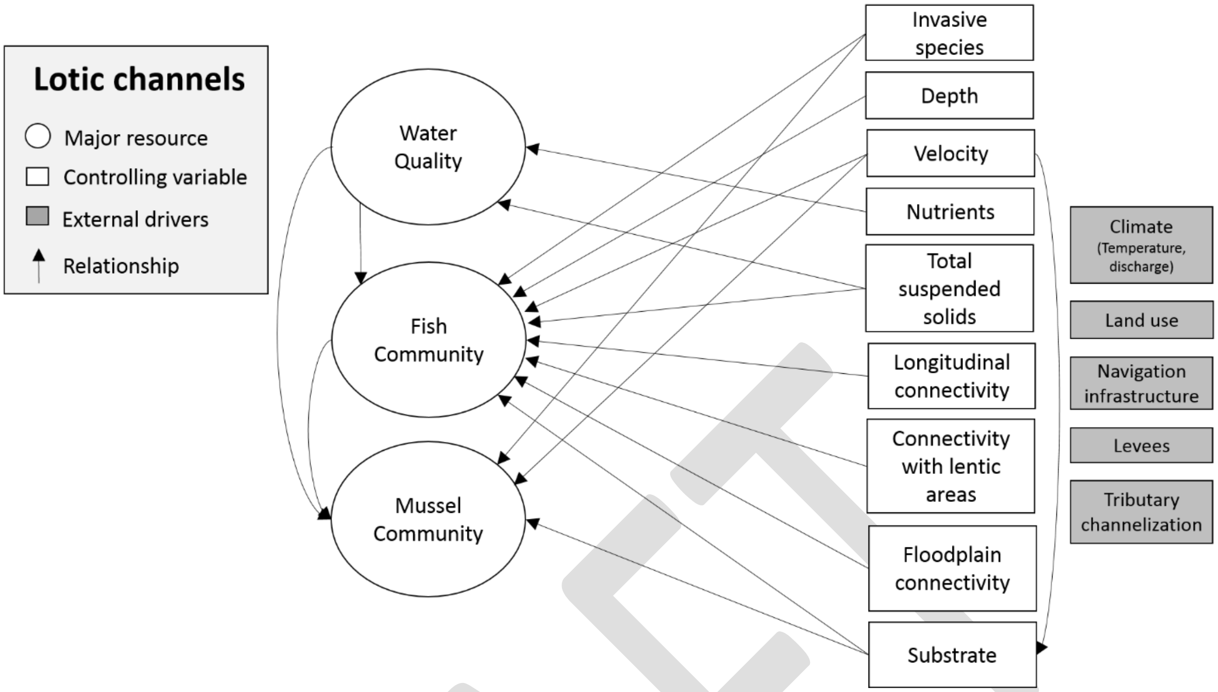
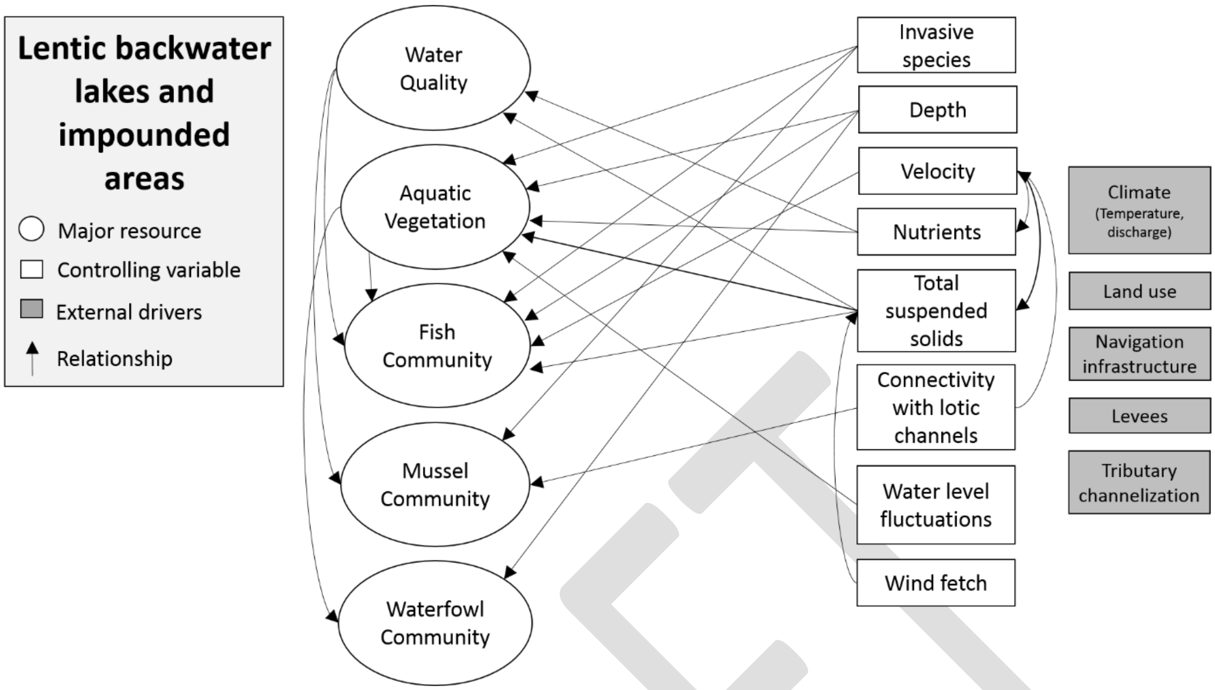

Lotic channels
Major resource
Controlling variable
External drivers
Relationship
Water Quality
Fish Community
Mussel Community
Invasive species
Depth
Velocity
Nutrients
Total suspended solids
Longitudinal connectivity
Connectivity with lentic areas
Floodplain connectivity
Substrate
Climate (Temperature, discharge)
Land use
Navigation infrastructure
Levees
Tributary channelization

Figure 5.



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1109 Figure 6.

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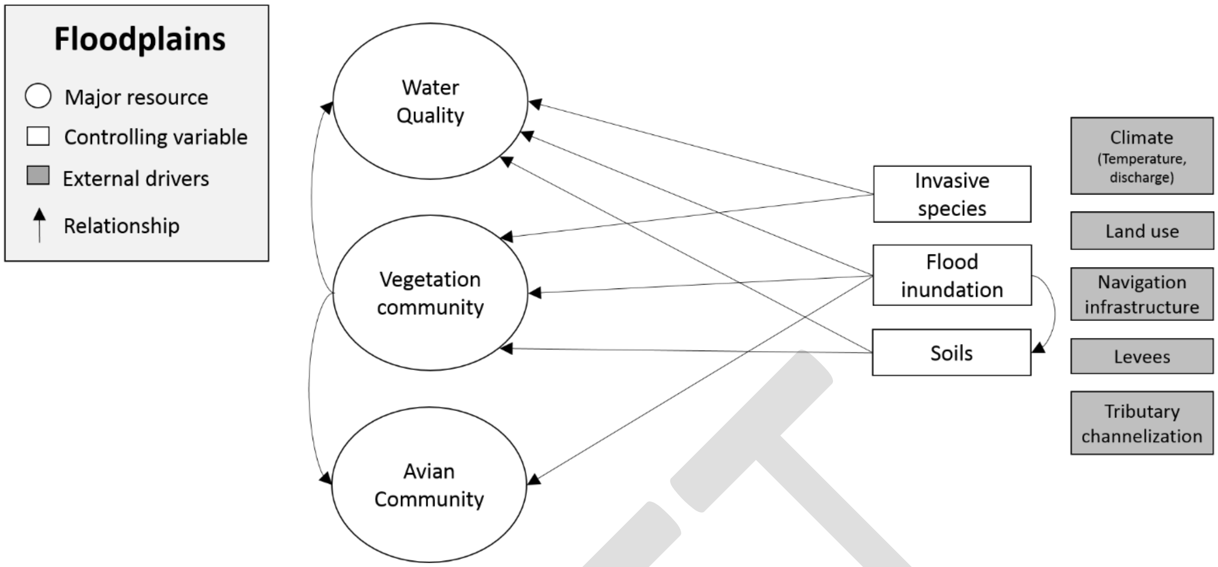
Floodplains
Major resource
Controlling variable
External drivers
Relationship
Water Quality
Vegetation community
Avian Community
Invasive species
Flood inundation
Soils
Climate
(Temperature, discharge)
Land use
Navigation infrastructure
Levees
Tributary channelization

Figure 7.

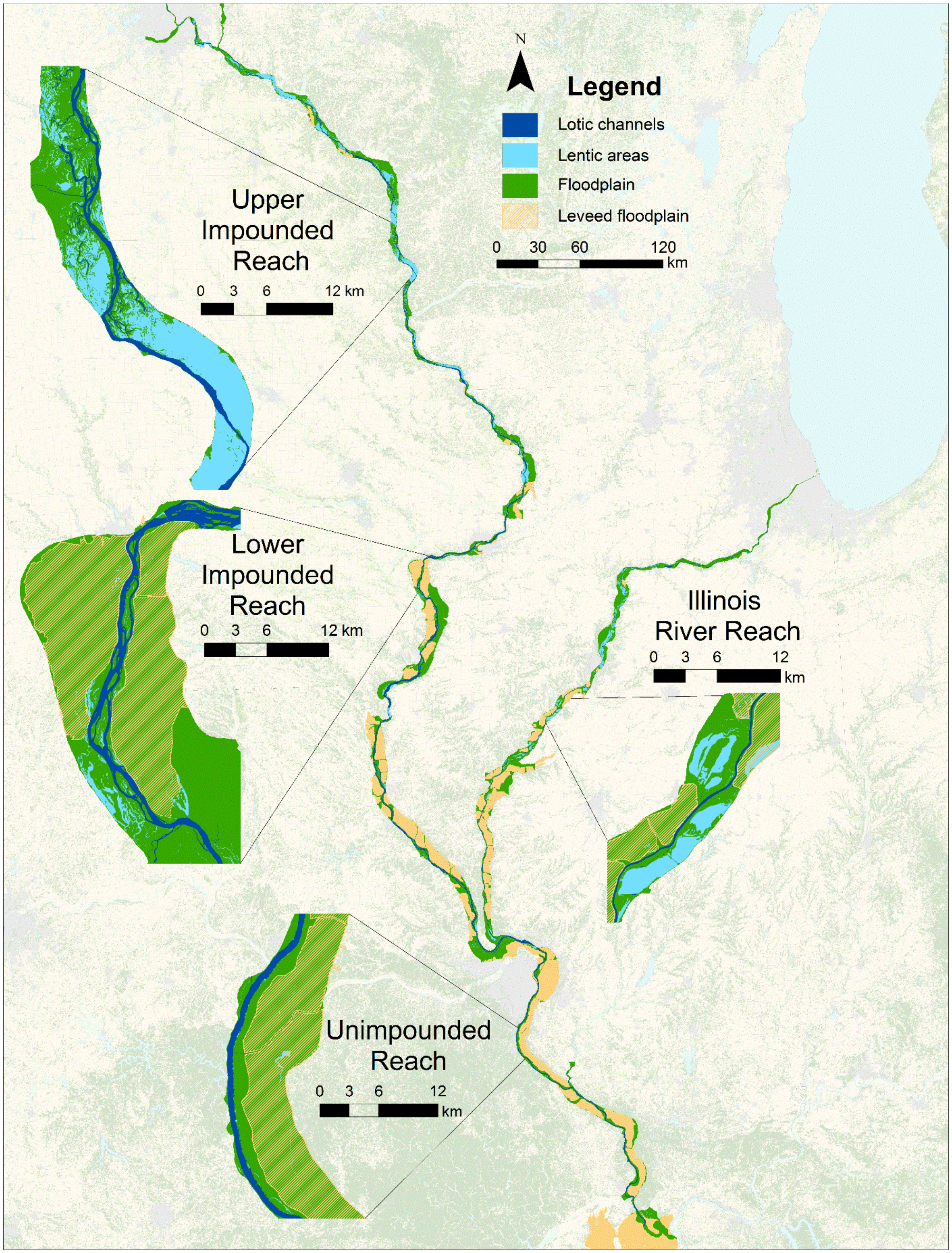
N
Legend
Lotic channels
Lentic areas
Floodplain
Leveed floodplain
0 30 60 120 km
Upper Impounded Reach
0 3 6 12 km
Lower Impounded Reach
0 3 6 12 km
Illinois River Reach
0 3 6 12 km
Unimpounded Reach
0 3 6 12 km

Figure 8.

ATTACHMENT E

<u>Additional Items</u>

- **Future Meeting Schedule** *(E-1)*
- **Frequently Used Acronyms (1/24/2017)** *(E-2 to E-7)*
- **UMRR Authorization, As Amended (1/27/15)** *(E-8 to E-11)*
- **UMRR (EMP) Operating Approach (5/06)** *(E-12)*

QUARTERLY MEETINGS
FUTURE MEETING SCHEDULE

MAY 2017	
St. Louis, Missouri	
May 23	UMRBA Quarterly Meeting
May 24	UMRR Coordinating Committee Quarterly Meeting

AUGUST 2017	
Onalaska/La Crosse, Wisconsin	
August 8	UMRBA Quarterly Meeting
August 9	UMRR Coordinating Committee Quarterly Meeting

Acronyms Frequently Used on the Upper Mississippi River System

AAR	After Action Report
A&E	Architecture and Engineering
ACRCC	Asian Carp Regional Coordinating Committee
AFB	Alternative Formulation Briefing
AHAG	Aquatic Habitat Appraisal Guide
AHRI	American Heritage Rivers Initiative
AIS	Aquatic Invasive Species
ALC	American Lands Conservancy
ALDU	Aquatic Life Designated Use(s)
AM	Adaptive Management
ANS	Aquatic Nuisance Species
AP	Advisory Panel
APE	Additional Program Element
ARRA	American Recovery and Reinvestment Act
ASA(CW)	Assistant Secretary of the Army for Civil Works
A-Team	Analysis Team
ATR	Agency Technical Review
AWI	America's Watershed Initiative
AWO	American Waterways Operators
AWQMN	Ambient Water Quality Monitoring Network
BA	Biological Assessment
BATIC	Build America Transportation Investment Center
BCR	Benefit-Cost Ratio
BMPs	Best Management Practices
BO	Biological Opinion
CAP	Continuing Authorities Program
CAWS	Chicago Area Waterways System
CCC	Commodity Credit Corporation
CCP	Comprehensive Conservation Plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CG	Construction General
CIA	Computerized Inventory and Analysis
CMMP	Channel Maintenance Management Plan
COE	Corps of Engineers
COPT	Captain of the Port
CPUE	Catch Per Unit Effort
CRA	Continuing Resolution Authority
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
CSP	Conservation Security Program
CUA	Cooperative Use Agreement
CWA	Clean Water Act
DALS	Department of Agriculture and Land Stewardship
DED	Department of Economic Development

DEM	Digital Elevation Model
DET	District Ecological Team
DEWS	Drought Early Warning System
DNR	Department of Natural Resources
DO	Dissolved Oxygen
DOA	Department of Agriculture
DOC	Department of Conservation
DOER	Dredging Operations and Environmental Research
DOT	Department of Transportation
DPR	Definite Project Report
DQC	District Quality Control/Quality Assurance
DSS	Decision Support System
EA	Environmental Assessment
ECC	Economics Coordinating Committee
EEC	Essential Ecosystem Characteristic
EIS	Environmental Impact Statement
EMAP	Environmental Monitoring and Assessment Program
EMAP-GRE	Environmental Monitoring and Assessment Program-Great Rivers Ecosystem
EMP	Environmental Management Program [Note: Former name of Upper Mississippi River Restoration Program.]
EMP-CC	Environmental Management Program Coordinating Committee
EO	Executive Order
EPA	Environmental Protection Agency
EPR	External Peer Review
EQIP	Environmental Quality Incentives Program
ER	Engineering Regulation
ERDC	Engineering Research & Development Center
ESA	Endangered Species Act
EWMN	Early Warning Monitoring Network
EWP	Emergency Watershed Protection Program
FACA	Federal Advisory Committee Act
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FDR	Flood Damage Reduction
FFS	Flow Frequency Study
FONSI	Finding of No Significant Impact
FRM	Flood Risk Management
FRST	Floodplain Restoration System Team
FSA	Farm Services Agency
FTE	Full Time Equivalent
FWCA	Fish & Wildlife Coordination Act
FWIC	Fish and Wildlife Interagency Committee
FWS	Fish and Wildlife Service
FWWG	Fish and Wildlife Work Group
FY	Fiscal Year
GAO	Government Accountability Office
GEIS	Generic Environmental Impact Statement

GI	General Investigations
GIS	Geographic Information System
GLC	Governors Liaison Committee
GLC	Great Lakes Commission
GLMRIS	Great Lakes and Mississippi River Interbasin Study
GPS	Global Positioning System
GREAT	Great River Environmental Action Team
GRP	Geographic Response Plan
HAB	Harmful Algal Bloom
HEL	Highly Erodible Land
HEP	Habitat Evaluation Procedure
HNA	Habitat Needs Assessment
HQUSACE	Headquarters, USACE
H.R.	House of Representatives
HREP	Habitat Rehabilitation and Enhancement Project
HU	Habitat Unit
HUC	Hydrologic Unit Code
IBA	Important Bird Area
IBI	Index of Biological (Biotic) Integrity
IC	Incident Commander
ICS	Incident Command System
ICWP	Interstate Council on Water Policy
IDIQ	Indefinite Delivery/Indefinite Quantity
IEPR	Independent External Peer Review
IIA	Implementation Issues Assessment
ILP	Integrated License Process
IMTS	Inland Marine Transportation System
IRCC	Illinois River Coordinating Council
IRPT	Inland Rivers, Ports & Terminals
IRTC	Implementation Report to Congress
IRWG	Illinois River Work Group
ISA	Inland Sensitivity Atlas
IWR	Institute for Water Resources
IWRM	Integrated Water Resources Management
IWTF	Inland Waterways Trust Fund
IWUB	Inland Waterways Users Board
IWW	Illinois Waterway
L&D	Lock(s) and Dam
LC/LU	Land Cover/Land Use
LDB	Left Descending Bank
LERRD	Lands, Easements, Rights-of-Way, Relocation of Utilities or Other Existing Structures, and Disposal Areas
LiDAR	Light Detection and Ranging
LMR	Lower Mississippi River
LMRCC	Lower Mississippi River Conservation Committee
LOI	Letter of Intent
LTRM	Long Term Resource Monitoring

M-35	Marine Highway 35
MAFC	Mid-America Freight Coalition
MARAD	U.S. Maritime Administration
MARC 2000	Midwest Area River Coalition 2000
MICRA	Mississippi Interstate Cooperative Resource Association
MIPR	Military Interdepartmental Purchase Request
MMR	Middle Mississippi River
MMRP	Middle Mississippi River Partnership
MNRG	Midwest Natural Resources Group
MOA	Memorandum of Agreement
MoRAST	Missouri River Association of States and Tribes
MOU	Memorandum of Understanding
MRAPS	Missouri River Authorized Purposes Study
MRBI	Mississippi River Basin (Healthy Watersheds) Initiative
MRC	Mississippi River Commission
MRCTI	Mississippi River Cities and Towns Initiative
MRRC	Mississippi River Research Consortium
MR&T	Mississippi River and Tributaries (project)
MSP	Minimum Sustainable Program
MVD	Mississippi Valley Division
MVP	St. Paul District
MVR	Rock Island District
MVS	St. Louis District
NAS	National Academies of Science
NAWQA	National Water Quality Assessment
NCP	National Contingency Plan
NIDIS	National Integrated Drought Information System (NOAA)
NEBA	Net Environmental Benefit Analysis
NECC	Navigation Environmental Coordination Committee
NED	National Economic Development
NEPA	National Environmental Policy Act
NESP	Navigation and Ecosystem Sustainability Program
NETS	Navigation Economic Technologies Program
NGO	Non-Governmental Organization
NGRREC	National Great Rivers Research and Education Center
NICC	Navigation Interests Coordinating Committee
NPDES	National Pollution Discharge Elimination System
NPS	Non-Point Source
NPS	National Park Service
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NRDAR	Natural Resources Damage Assessment and Restoration
NRT	National Response Team
NSIP	National Streamflow Information Program
NWI	National Wetlands Inventory
NWR	National Wildlife Refuge
O&M	Operation and Maintenance

OHWM	Ordinary High Water Mark
OMB	Office of Management and Budget
OMRR&R	Operation, Maintenance, Repair, Rehabilitation, and Replacement
OPA	Oil Pollution Act of 1990
ORSANCO	Ohio River Valley Water Sanitation Commission
OSC	On-Scene Coordinator
OSE	Other Social Effects
OSIT	On Site Inspection Team
P3	Public-Private Partnerships
PA	Programmatic Agreement
PAS	Planning Assistance to States
P&G	Principles and Guidelines
P&R	Principles and Requirements
P&S	Plans and Specifications
P&S	Principles and Standards
PCA	Pollution Control Agency
PCA	Project Cooperation Agreement
PCX	Planning Center of Expertise
PDT	Project Delivery Team
PED	Preliminary Engineering and Design
PgMP	Program Management Plan
PILT	Payments In Lieu of Taxes
PIR	Project Implementation Report
PL	Public Law
PMP	Project Management Plan
PORT	Public Outreach Team
PPA	Project Partnership Agreement
PPT	Program Planning Team
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RCP	Regional Contingency Plan
RCPP	Regional Conservation Partnership Program
RDB	Right Descending Bank
RED	Regional Economic Development
RIFO	Rock Island Field Office
RM	River Mile
RP	Responsible Party
RPT	Reach Planning Team
RRAT	River Resources Action Team
RRCT	River Resources Coordinating Team
RRF	River Resources Forum
RRT	Regional Response Team
RST	Regional Support Team
RTC	Report to Congress
S.	Senate
SAV	Submersed Aquatic Vegetation
SDWA	Safe Drinking Water Act

SEMA	State Emergency Management Agency
SET	System Ecological Team
SONS	Spill of National Significance
SOW	Scope of Work
SRF	State Revolving Fund
SWCD	Soil and Water Conservation District
T&E	Threatened and Endangered
TEUs	twenty-foot equivalent units
TIGER	Transportation Investment Generating Economic Recovery
TLP	Traditional License Process
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
TSS	Total Suspended Solids
TVA	Tennessee Valley Authority
TWG	Technical Work Group
UMESC	Upper Midwest Environmental Sciences Center
UMIMRA	Upper Mississippi, Illinois, and Missouri Rivers Association
UMR	Upper Mississippi River
UMRBA	Upper Mississippi River Basin Association
UMRBC	Upper Mississippi River Basin Commission
UMRCC	Upper Mississippi River Conservation Committee
UMRCP	Upper Mississippi River Comprehensive Plan
UMR-IWW	Upper Mississippi River-Illinois Waterway
UMRNWFR	Upper Mississippi River National Wildlife and Fish Refuge
UMRR	Upper Mississippi River Restoration Program [Note: Formerly known as Environmental Management Program.]
UMRS	Upper Mississippi River System
UMWA	Upper Mississippi Waterway Association
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VTC	Video Teleconference
WCI	Waterways Council, Inc.
WES	Waterways Experiment Station (replaced by ERDC)
WHAG	Wildlife Habitat Appraisal Guide
WHIP	Wildlife Habitat Incentives Program
WLMTF	Water Level Management Task Force
WQ	Water Quality
WQEC	Water Quality Executive Committee
WQTF	Water Quality Task Force
WQS	Water Quality Standard
WRDA	Water Resources Development Act
WRP	Wetlands Reserve Program
WRRDA	Water Resources Reform and Development Act

Upper Mississippi River Restoration Program Authorization

Section 1103 of the Water Resources Development Act of 1986 (P.L. 99-662) as amended by
Section 405 of the Water Resources Development Act of 1990 (P.L. 101-640),
Section 107 of the Water Resources Development Act of 1992 (P.L. 102-580),
Section 509 of the Water Resources Development Act of 1999 (P.L. 106-53),
Section 2 of the Water Resources Development Technical Corrections of 1999 (P.L. 106-109), and
Section 3177 of the Water Resources Development Act of 2007 (P.L. 110-114).

Additional Cost Sharing Provisions

Section 906(e) of the Water Resources Development Act of 1986 (P.L. 99-662) as amended by
Section 221 of the Water Resources Development Act of 1999 (P.L. 106-53).

SEC. 1103. UPPER MISSISSIPPI RIVER PLAN.

(a)(1) This section may be cited as the "Upper Mississippi River Management Act of 1986".

(2) To ensure the coordinated development and enhancement of the Upper Mississippi River system, it is hereby declared to be the intent of Congress to recognize that system as a nationally significant ecosystem and a nationally significant commercial navigation system. Congress further recognizes that the system provides a diversity of opportunities and experiences. The system shall be administered and regulated in recognition of its several purposes.

(b) For purposes of this section --

(1) the terms "Upper Mississippi River system" and "system" mean those river reaches having commercial navigation channels on the Mississippi River main stem north of Cairo, Illinois; the Minnesota River, Minnesota; Black River, Wisconsin; Saint Croix River, Minnesota and Wisconsin; Illinois River and Waterway, Illinois; and Kaskaskia River, Illinois;

(2) the term "Master Plan" means the comprehensive master plan for the management of the Upper Mississippi River system, dated January 1, 1982, prepared by the Upper Mississippi River Basin Commission and submitted to Congress pursuant to Public Law 95-502;

(3) the term "GREAT I, GREAT II, and GRRM studies" means the studies entitled "GREAT Environmental Action Team--GREAT I--A Study of the Upper Mississippi River", dated September 1980, "GREAT River Environmental Action Team--GREAT II--A Study of the Upper Mississippi River", dated December 1980, and "GREAT River Resource Management Study", dated September 1982; and

(4) the term "Upper Mississippi River Basin Association" means an association of the States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin, formed for the purposes of cooperative effort and united assistance in the comprehensive planning for the use, protection, growth, and development of the Upper Mississippi River System.

(c)(1) Congress hereby approves the Master Plan as a guide for future water policy on the Upper Mississippi River system. Such approval shall not constitute authorization of any recommendation contained in the Master Plan.

(2) Section 101 of Public Law 95-502 is amended by striking out the last two sentences of subsection (b), striking out subsection (i), striking out the final sentence of subsection (j), and redesignating subsection "(j)" as subsection "(i)".

(d)(1) The consent of the Congress is hereby given to the States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin, or any two or more of such States, to enter into negotiations for agreements, not in conflict with any law of the United States, for cooperative effort and mutual assistance in the comprehensive planning for the use, protection, growth, and development of the Upper Mississippi River system, and to establish such agencies, joint or otherwise, or designate an existing multi-State entity, as they may deem desirable for making effective such agreements. To the extent required by Article I, section 10 of the Constitution, such agreements shall become final only after ratification by an Act of Congress.

(2) The Secretary is authorized to enter into cooperative agreements with the Upper Mississippi River Basin Association or any other agency established under paragraph (1) of this subsection to promote and facilitate active State government participation in the river system management, development, and protection.

(3) For the purpose of ensuring the coordinated planning and implementation of programs authorized in subsections (e) and (h)(2) of this section, the Secretary shall enter into an interagency agreement with the Secretary of the Interior to provide for the direct participation of, and transfer of funds to, the Fish and Wildlife Service and any other agency or bureau of the Department of the Interior for the planning, design, implementation, and evaluation of such programs.

(4) The Upper Mississippi River Basin Association or any other agency established under paragraph (1) of this subsection is hereby designated by Congress as the caretaker of the master plan. Any changes to the master plan recommended by the Secretary shall be submitted to such association or agency for review. Such association or agency may make such comments with respect to such recommendations and offer other recommended changes to the master plan as such association or agency deems appropriate and shall transmit such comments and other recommended changes to the Secretary. The Secretary shall transmit such recommendations along with the comments and other recommended changes of such association or agency to the Congress for approval within 90 days of the receipt of such comments or recommended changes.

(e) Program Authority

(1) Authority

(A) In general. The Secretary, in consultation with the Secretary of the Interior and the States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin, may undertake, as identified in the master plan

(i) a program for the planning, construction, and evaluation of measures for fish and wildlife habitat rehabilitation and enhancement; and

(ii) implementation of a long-term resource monitoring, computerized data inventory and analysis, and applied research program, including research on water quality issues affecting the Mississippi River (including elevated nutrient levels) and the development of remediation strategies.

(B) Advisory committee. In carrying out subparagraph (A)(i), the Secretary shall establish an independent technical advisory committee to review projects, monitoring plans, and habitat and natural resource needs assessments.

(2) REPORTS. — Not later than December 31, 2004, and not later than December 31 of every sixth year thereafter, the Secretary, in consultation with the Secretary of the Interior and the States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin, shall submit to Congress a report that —

(A) contains an evaluation of the programs described in paragraph (1);

(B) describes the accomplishments of each of the programs;

(C) provides updates of a systemic habitat needs assessment; and

(D) identifies any needed adjustments in the authorization of the programs.

(3) For purposes of carrying out paragraph (1)(A)(i) of this subsection, there is authorized to be appropriated to the Secretary $22,750,000 for fiscal year 1999 and each fiscal year thereafter.

(4) For purposes of carrying out paragraph (1)(A)(ii) of this subsection, there is authorized to be appropriated to the Secretary $10,420,000 for fiscal year 1999 and each fiscal year thereafter.

(5) Authorization of appropriations.—There is authorized to be appropriated to carry out paragraph (1)(B) $350,000 for each of fiscal years 1999 through 2009.

(6) Transfer of amounts.—For fiscal year 1999 and each fiscal year thereafter, the Secretary, in consultation with the Secretary of the Interior and the States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin, may transfer not to exceed 20 percent of the amounts appropriated to carry out clause (i) or (ii) of paragraph (1)(A) to the amounts appropriated to carry out the other of those clauses.

(7)(A) Notwithstanding the provisions of subsection (a)(2) of this section, the costs of each project carried out pursuant to paragraph (1)(A)(i) of this subsection shall be allocated between the Secretary and the appropriate non-Federal sponsor in accordance with the provisions of section 906(e) of this Act; except that the costs of operation and maintenance of projects located on Federal lands or lands owned or operated by a State or local government shall be borne by the Federal, State, or local agency that is responsible for management activities for fish and wildlife on such lands and, in the case of any project requiring non-Federal cost sharing, the non-Federal share of the cost of the project shall be 35 percent.

(B) Notwithstanding the provisions of subsection (a)(2) of this section, the cost of implementing the activities authorized by paragraph (1)(A)(ii) of this subsection shall be allocated in accordance with the provisions of section 906 of this Act, as if such activity was required to mitigate losses to fish and wildlife.

(8) None of the funds appropriated pursuant to any authorization contained in this subsection shall be considered to be chargeable to navigation.

(f) (1) The Secretary, in consultation with any agency established under subsection (d)(1) of this section, is authorized to implement a program of recreational projects for the system substantially in accordance with the recommendations of the GREAT I, GREAT II, and GRRM studies and the master plan reports. In addition, the Secretary, in consultation with any such agency, shall, at Federal expense, conduct an assessment of the economic benefits generated by recreational activities in the system. The cost of each such project shall be allocated between the Secretary and the appropriate non-Federal sponsor in accordance with title I of this Act.

(2) For purposes of carrying out the program of recreational projects authorized in paragraph (1) of this subsection, there is authorized to be appropriated to the Secretary not to exceed $500,000 per fiscal year for each of the first 15 fiscal years beginning after the effective date of this section.

(g) The Secretary shall, in his budget request, identify those measures developed by the Secretary, in consultation with the Secretary of Transportation and any agency established under subsection (d)(1) of this section, to be undertaken to increase the capacity of specific locks throughout the system by employing nonstructural measures and making minor structural improvements.

(h)(1) The Secretary, in consultation with any agency established under subsection (d)(1) of this section, shall monitor traffic movements on the system for the purpose of verifying lock capacity, updating traffic projections, and refining the economic evaluation so as to verify the need for future capacity expansion of the system.

(2) Determination.

(A) In general. The Secretary in consultation with the Secretary of the Interior and the States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin, shall determine the need for river rehabilitation and environmental enhancement and protection based on the condition of the environment, project developments, and projected environmental impacts from implementing any proposals resulting from recommendations made under subsection (g) and paragraph (1) of this subsection.

(B) Requirements. The Secretary shall

(i) complete the ongoing habitat needs assessment conducted under this paragraph not later than September 30, 2000; and

(ii) include in each report under subsection (e)(2) the most recent habitat needs assessment conducted under this paragraph.

(3) There is authorized to be appropriated to the Secretary such sums as may be necessary to carry out this subsection.

(i) (1) The Secretary shall, as he determines feasible, dispose of dredged material from the system pursuant to the recommendations of the GREAT I, GREAT II, and GRRM studies.

(2) The Secretary shall establish and request appropriate Federal funding for a program to facilitate productive uses of dredged material. The Secretary shall work with the States which have, within their boundaries, any part of the system to identify potential users of dredged material.

(j) The Secretary is authorized to provide for the engineering, design, and construction of a second lock at locks and dam 26, Mississippi River, Alton, Illinois and Missouri, at a total cost of $220,000,000, with a first Federal cost of $220,000,000. Such second lock shall be constructed at or in the vicinity of the location of the replacement lock authorized by section 102 of Public Law 95-502. Section 102 of this Act shall apply to the project authorized by this subsection.

SEC. 906(e). COST SHARING.

(e) In those cases when the Secretary, as part of any report to Congress, recommends activities to enhance fish and wildlife resources, the first costs of such enhancement shall be a Federal cost when--

(1) such enhancement provides benefits that are determined to be national, including benefits to species that are identified by the National Marine Fisheries Service as of national economic importance, species that are subject to treaties or international convention to which the United States is a party, and anadromous fish;

(2) such enhancement is designed to benefit species that have been listed as threatened or endangered by the Secretary of the Interior under the terms of the Endangered Species Act, as amended (16 U.S.C. 1531, et seq.), or

(3) such activities are located on lands managed as a national wildlife refuge.

When benefits of enhancement do not qualify under the preceding sentence, 25 percent of such first costs of enhancement shall be provided by non-Federal interests under a schedule of reimbursement determined by the Secretary. Not more than 80 percent of the non-Federal share of such first costs may be satisfied through in-kind contributions, including facilities, supplies, and services that are necessary to carry out the enhancement project. The non-Federal share of operation, maintenance, and rehabilitation of activities to enhance fish and wildlife resources shall be 25 percent.

EMP OPERATING APPROACH

2006 marks the 20th anniversary of the Environmental Management Program (EMP). During that time, the Program pioneered many new ideas to help deliver efficient and effective natural resource programs to the Upper Mississippi River System (UMRS). These included the creation of an effective partnership of five states, five federal agencies, and numerous NGOs; a network of six field stations monitoring the natural resources of the UMRS; and the administrative structure to encourage river managers to use both new and proven environmental restoration techniques.

EMP has a history of identifying and dealing with both natural resource and administrative challenges. The next several years represent new opportunities and challenges as Congress considers authorization of the Navigation and Environmental Sustainability Program (NESP), possible integration or merger of EMP with NESP, and changing standards for program management and execution.

We will continue to learn from both the history of EMP and experience of other programs. Charting a course for EMP over the next several years is important to the continued success of the Program. EMP will focus on the key elements of partnership, regional administration and coordination, LTRMP, and HREPs.

The fundamental focus of EMP will not change, however the way we deliver our services must change and adapt. This will include:

- further refinements in regional coordination and management,
- refinement of program goals and objectives,
- increased public outreach efforts,
- development and use of tools such as the regional HREP database and HREP Handbook,
- exploring new delivery mechanisms for contracting,
- continued refinement of the interface between LTRMP and the HREP program components, and
- scientific and management application of LTRMP information and data.

The focus of these efforts must benefit the resources of the UMRS through efficient and effective management.