US Army Corps of Engineers ®
Kansas City District

APPENDIX A
Project History

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Missouri River Recovery Program
Missouri River Bank Stabilization and Navigation
Fish and Wildlife Mitigation Project

March 2012

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ENCLOSURE 1 – 2011 ORIGINAL JAMESON ISLAND CHUTE PROJECT

File

Matt Blunt, Governor • Doyle Childers, Director

STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES

www.dnr.mo.gov

September 13, 2007

Colonel Roger A. Wilson, Jr.
District Commander
U.S. Army Corps of Engineers
700 Federal Building
Kansas City, Missouri 64108-2896

Dear Colonel Wilson:

Enclosed you will find an order adopted by the Missouri Clean Water Commission at their September 12, 2007 meeting. Please feel free to contact me with any questions at (573) 751-6721 or Department of Natural Resources, Water Protection Program, P.O. Box 176, Jefferson City, Missouri 65102. The attorney for the Commission is Ms. Mary Bryan, assistant attorney general for the state of Missouri. She may be reached at (573) 751-3640 or Attorney General's Office, P. O. Box 899, Jefferson City, Missouri 65101.

Sincerely,

MISSOURI CLEAN WATER COMMISSION

for Edward Galbraith
Director of Staff

EG/mco

c: Missouri Clean Water Commission
Ms. Mary Bryan, Attorney General's Office

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ENCLOSURE 2

ORDER
OF THE MISSOURI CLEAN WATER COMMISSION

In light of recent letters from Governor Blunt affirming the powers of the Missouri Clean Water Commission, the letter from Colonel Roger Wilson of the U.S. Army Corps of Engineers requesting that the Missouri Clean Water Commission (the "Commission") clarify its position, and the permit application for the Barney Bend project, it is appropriate that the Commission state its current policy regarding the discharge of millions of tons of sediment into the Missouri River by the U.S. Army Corps of Engineers in cooperation with the U.S. Fish and Wildlife Service:

1. Under 644.029(9),RSMo, the Commission may issue orders prohibiting or abating discharges of water contaminants into the waters of the state or adopt other remedial measures to prevent, control or abate pollution.

2. Under both federal and Missouri Clean Water Law, sediment is a pollutant and its discharge into a waterbody is pollution.

3. The permits issued to the U.S. Army Corps of Engineers for habitat restoration projects under general permit MO-G69900 are for return water and stormwater runoff and do not specifically grant the discharge of soils into the waters of Missouri.

4. Therefore, the Commission hereby prohibits and orders the immediate abatement of the discharge of sediment into the waters of Missouri by all habitat restoration projects.

It is hereby **ORDERED** that all sediment of all habitat restoration projects excavated or designed to erode shall be placed on land with such a design that it will not enter the waters of Missouri now or in the future. Section 644.071, RSMo, provides that this Order may be subject to judicial review.

Issued: September 12, 2007

MISSOURI CLEAN WATER COMMISSION

Kristin M Perry _____ _____

Frank L. Sharrow _____ _____

Tom M. Hunter _____ _____

Ron Hardecker _____ _____

William A. Easley _____ _____

Jan Tupper participated by phone and joined in voting in favor of this order. – Kristin Perry, vice-chair.

BEFORE THE MISSOURI CLEAN WATER COMMISSION

In re: USACE Shallow Water Habitat Construction Projects	)	**No. 07-001**
	)	

AMENDED ORDER

Under 644.026.1(9), RSMo, the Commission may issue orders prohibiting or abating discharges of water contaminants into the waters of the state or adopt other remedial measures to prevent, control or abate pollution.

1. Sediment is a pollutant under the Federal Clean Water Act and a water contaminant under the Missouri Clean Water Law.

2. General Permit MO-G69900 as issued to the U.S. Army Corps of Engineers' for certain habitat construction projects on the Missouri River authorizes the Corps to discharge return water and storm water runoff and does not authorize the discharge of sediment or soil into the waters of Missouri.

3. The Corps' activities in connection with the aforementioned shallow water habitat construction projects, as approved by the U.S. Fish & Wildlife Service, have resulted in the unauthorized discharge of excessive sediment into the waters of Missouri, in violation of § 644.051.1(3), RSMo.

4. The Commission, the Missouri Department of Natural Resources and the U.S. Environmental Protection Agency have imposed significant fines and penalties against various entities related to the discharge of sediment into the waters of Missouri, and required those persons to stop discharging.

Therefore, the Commission hereby prohibits and orders the immediate cessation of the discharge of sediment and topsoil into the waters of Missouri by the Corps in connection with the construction of all Missouri River shallow water habitat construction projects.

It is hereby **ORDERED** that the Corps' shall, for all Missouri River shallow water habitat construction projects, put to beneficial reuse consistent with this Amended Order or place on land in accordance with an individual permit or certification for each specific site, all topsoil and excavated sediments. No sediment or topsoil disturbed by construction activities at said projects shall enter the waters of Missouri now or in the future, except in *de minimis* amounts related to normal construction and operation as provided in the applicable approvals by the Missouri Department of Natural Resources.

This Order supersedes the Commission's Order dated September 12, 2007. Section 644.071, RSMo, provides that this Order may be subject to judicial review.

Issued: March 12, 2008

ENCLOSURE 3

Kristin M. Perry
Chair

Ron Hardecke
Vice-Chair

Samuel M. Hunter
Commissioner

Frank L. Shorney
Commissioner

Ben A. "Todd" Parnell, III
Commissioner

Kristin M. Perry
Chair

Ron Hardecke
Vice-Chair

Samuel M. Hunter
Commissioner

Frank L. Shorney
Commissioner

Ben A. "Todd" Parnell, III
Commissioner

Kristin M. Perry
Chair

Ron Hardecke
Vice-Chair

Samuel M. Hunter
Commissioner

Frank L. Shorney
Commissioner

Ben A. "Todd" Parnell, III
Commissioner

Vice-Chair

Samuel M. Hunter
Commissioner

Frank L. Shorney
Commissioner

Ben A. "Todd" Parnell, III
Commissioner

FEDERAL POSITION ON SEDIMENT MANAGEMENT
MISSOURI RIVER RECOVERY, SHALLOW WATER HABITAT CREATION
DOWNSTREAM OF GAVINS POINT DAM

10 JANUARY 2011
(SUPERSEDES THE 14 FEBRUARY 2008 POSITION)

The signatory federal agencies support creation of shallow water habitat (SWH) in furtherance of the requirements to mitigate habitat losses, as specified by the U.S. Fish and Wildlife Service Missouri River Biological Opinions[1], and in accordance with their respective statutory responsibilities. Federal agencies recognize the importance of receiving-water characteristics (i.e., the natural, chemical and physical condition of each specific waterbody and the associated water quality requirements of its resident aquatic life) in relation to the Clean Water Act. The National Academies[2] provided recommendations to the U.S. Army Corps of Engineers for improved sediment management and adaptive processes in association with the Missouri River Recovery Program, including SWH creation projects. In creating SWH, and specifically at sites where sediment contribution to the Missouri River is likely, the signatory agencies shall:

1) Continue to ensure decisions are formulated to enhance and protect native species, aquatic life, and designated beneficial uses. The Missouri River Biological Opinions raised awareness regarding the return of sediment to the Missouri River to support endangered native species. Creation of SWH is for the purpose of benefiting native species adversely affected by the loss of historical physical habitat, loss of natural riverine processes, and reduced alluvial sediment load. The U.S. Army Corps of Engineers has chosen SWH creation methods (dredging, side-cast, etc.) that favor restoration of natural processes to support endangered native species, with regard for pre-project site characterization through soil, water, and elutriate tests, while also maintaining all authorized purposes (e.g. the 1944 Flood Control Act) and compliance with the Clean Water Act.

2) Monitor representative SWH sites to answer key questions such as effects and or benefits of SWH creation on water quality and primary productivity. Recommendations from the National Academies, which stress the importance of learning over time, will be considered when developing monitoring plan(s) and adaptive processes for SWH creation.

3) Continue to implement project activities in compliance with all laws, for example the Clean Water Act (including permit compliance and Section 401 Certification), Fish and Wildlife Coordination Act, Endangered Species Act, National Environmental Policy Act, Water Resource Development Act, Flood Control Act, River and Harbor Act, Wild and Scenic Rivers Act, and Data Quality Act.

[1] U.S. Fish and Wildlife Service (USFWS). 2003. Amendment to the 2000 Biological Opinion on the Operation of the Missouri River Main Stem Reservoir System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System.

[2] National Research Council (NRC). 2010. Pre-publication Copy. Missouri River Planning: Recognizing and Incorporating Sediment Management. Washington, D. C. National Academies Press.

ENCLOSURE 4

FEDERAL POSITION ON SEDIMENT MANAGEMENT
MISSOURI RIVER RECOVERY, SHALLOW WATER HABITAT CREATION
DOWNSTREAM OF GAVINS POINT DAM

SIGNATORY AGENCIES

U.S. ARMY CORPS OF ENGINEERS

Commander, Northwestern Division — 1/10/11 Date

U.S. FISH AND WILDLIFE SERVICE

Acting Regional Director, Region 3 — 1/10/11 Date

Regional Director, Region 6 — 1/10/11 Date

ENVIRONMENTAL PROTECTION AGENCY

Regional Administrator, Region 7 — 1/6/11 Date

NATIONAL PARK SERVICE

Regional Director, Midwest Region — 1-11-2011 Date

STATE OF MISSOURI

DEPARTMENT OF NATURAL RESOURCES

MISSOURI CLEAN WATER COMMISSION

MISSOURI STATE OPERATING PERMIT

GENERAL PERMIT

In compliance with the Missouri Clean Water Law, (Chapter 644 R.S. Mo. as amended, hereinafter, the Law), and the Federal Water Pollution Control Act (Public Law 92-500, 92nd Congress) as amended,

MO-G699000

is authorized to discharge from the facility described herein, in accordance with the effluent limitations and monitoring requirements as set forth herein:

FACILITY DESCRIPTION

All Outfalls

Habitat Restoration Projects: return water and stormwater runoff from dredged material deposition sites, bank notching/chute excavation to allow the river to actively scour and widen and other disturbance along the Missouri and Mississippi Rivers for fish and wildlife mitigation projects and shallow water habitat development projects.

This permit authorizes only wastewater, including storm waters, discharges under the Missouri Clean Water Law and the National Pollutant Discharge Elimination System; it does not apply to other regulated areas. This permit may be appealed in accordance with Section 644.051.6 of the Law.

August 19, 2005
Effective Date

Doyle Childers, Director, Department of Natural Resources
Executive Secretary, Clean Water Commission

August 18, 2010
Expiration Date

Edward Galbraith, Director of Staff, Clean Water Commission

MO 780-0041 (10-03)

ENCLOSURE 5

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

1. Discharges shall not violate Water Quality Standards 10 CSR 20-7.031.

2. There are no regular sampling requirements in this permit. However, the department may require sampling and reporting as a result of illegal discharges, compliance issues, complaint investigations, or other such evidence of off-site contamination outside the scope of the proposed activities. If such an action is needed, the department will specify in writing any additional sampling requirements, including such information as location, extent, and parameters.

STANDARD CONDITIONS

In addition to specified conditions stated herein, this permit is subject to the attached Part I standard conditions dated October 1, 1980, and hereby incorporated as though fully set forth herein.

APPLICABILITY

1. This permit authorizes the discharge of return water and stormwater from dredged material deposition sites, bank notching/chute excavation to allow the river to actively scour and widen and other disturbance resulting from habitat construction projects along the Missouri and Mississippi Rivers for fish and wildlife mitigation projects and shallow water habitat development projects owned or constructed by the U.S. Army Corps of Engineers to waters of the state of Missouri. A Missouri State Operating Permit that specifically identifies the project must be issued before any construction can occur.

2. This permit does not apply to discharges to streams or lakes other than the Missouri or Mississippi Rivers and adjacent wetlands.
3. This permit will not be issued for discharges within 1000 feet of drinking water supply intakes.

4. This permit will not be issued for discharges within two stream miles upstream of biocriteria reference locations identified or described in 10 CSR 20, Chapter 7. These regulations are available at many libraries or on the internet at http://www.sos.state.mo.us/adrules/csr/csr.asp. A site specific permit will be required if these conditions exist.

5. This general permit does not authorize directing storm waters across private property not owned or operated by the permittee.

6. This general permit does not authorize any discharge to waters of the state of sewage, process wastewaters, or pollutants such as:
   (a) Hazardous substances and oil and grease that may be contained in dredged sediment,
   (b) Wastewater generated from air pollution control equipment or the containment of scrubber water in lined ponds, or
   (c) Domestic wastewaters, including gray waters.

7. If at any time the Missouri Department of Natural Resources determines that the quality of waters of the state may be better protected by requiring the owner/operator of the permitted site to apply for a site specific permit, the department may require any person to obtain a site specific operating permit [10 CSR 20-6.010 (13) and 10 CSR 20-6.200(5)].

   The department may require the permittee to apply for and obtain a site specific or different general permit if:

   (a) The permittee is not in compliance with the conditions of this general permit;
   (b) The discharge no longer qualifies for this general permit due to changed site conditions and regulations; or
   (c) Information becomes available that indicates water quality standards have been or may be violated.

8. Any owner/operator authorized by a general permit may request to be excluded from the coverage of the general permit and apply for a site specific permit [10 CSR 20-6.010 (13) and 10 CSR 20-6.200(5)].

REQUIREMENTS AND POLLUTION PREVENTION PLAN GUIDELINES

Note: These requirements do not supersede nor remove liability for compliance with county and other local ordinances.

1. Water Quality Standards
   (a) Discharges to waters of the state shall not cause a violation of water quality standards rule under 10 CSR 20-7.031, including both specific and general criteria.
   (b) General Criteria. The following general water quality criteria shall be applicable to all waters of the state at all times including mixing zones. No water contaminant, by itself or in combination with other substances, shall prevent the waters of the state from meeting the following conditions:
      (1) Waters shall be free from substances in sufficient amounts to cause the formation of putrescent, unsightly or harmful bottom deposits or prevent full maintenance of beneficial uses;
      (2) Waters shall be free from oil, scum and floating debris in sufficient amounts to be unsightly or prevent full maintenance of beneficial uses;
      (3) Waters shall be free from substances in sufficient amounts to cause unsightly color or turbidity, offensive odor or prevent full maintenance of beneficial uses;
      (4) Waters shall be free from substances or conditions in sufficient amounts to result in toxicity to human, animal or aquatic life;
      (5) There shall be no significant human health hazard from incidental contact with the water;
      (6) There shall be no acute toxicity to livestock or wildlife watering;
      (7) Waters shall be free from physical, chemical or hydrologic changes that would impair the natural biological community;
      (8) Waters shall be free from used tires, car bodies, appliances, demolition debris, used vehicles or equipment and solid waste as defined in Missouri's Solid Waste Law, section 260.200, RSMo, except as the use of such materials is specifically permitted pursuant to section 260.200-260.247.

2. Good housekeeping practices shall be maintained on the site to keep solid waste from entry into waters of the state.

3. All fueling facilities present on the site shall adhere to applicable federal and state regulations concerning underground storage, aboveground storage, and dispensers, including spill prevention, control and counter measures.

4. Substances regulated by federal law under the Resource Conservation and Recovery Act (RCRA) or the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) that are transported, stored, or used for maintenance, cleaning or repair shall be managed according to the provisions of RCRA and CERCLA.

5. An individual shall be designated by the permittee as responsible for environmental matters. Staff of the permitted facility shall ensure that Best Management Practices (BMPs) are continually implemented and effective.

6. This permit may be reopened and modified, or alternatively revoked and reissued, to:
   (a) Comply with any applicable effluent standard or limitation issued or approved under Sections 301(b)(2)(C) and (D), 304(b)(2), and 307(a) (2) of the Clean Water Act, if the effluent standard or limitation so issued or approved:
      (1) contains different conditions or is otherwise more stringent than any effluent limitation in the permit or
      (2) controls any pollutant not limited in the permit.
   (b) Incorporate new or modified effluent limitations or other conditions, if the result of a waste load allocation study, toxicity test or other information indicates changes are necessary to assure compliance with Missouri's Water Quality Standards.
   (c) Incorporate new or modified effluent limitations or other conditions if, as the result of a watershed analysis, a Total Maximum Daily Load (TMDL) limitation is developed for the receiving waters which are currently included in Missouri's list of waters of the state not fully achieving the state's water quality standards, also called the 303(d) list.

   The permit as modified or reissued under this paragraph shall also contain any other requirements of the Clean Water Act then applicable.

7. In the event soil contamination or hazardous substances are discovered at the site during dredging activities, the permittee shall request guidance from the Department's Hazardous Waste Program in writing.

TRANSFER OF OWNERSHIP

This permit may be transferred to a new owner by submitting an "Application for Transfer of Operating Permit" signed by the seller and buyer of the facility, along with the appropriate modification fee.

TERMINATION

In order to terminate the permit, the permittee shall notify MDNR by submitting Form H, included with the State Operating Permit. The permittee shall complete Form H and mail it to MDNR at the address noted in the cover letter of this permit.

This general permit will expire five years from the effective date of the permit (see page 1). The issue date is the date the State Operating Permit is issued to the applicant. The expiration date may or may not coincide with the date the authorized project or development is scheduled for completion.

If the project completion date will be after the expiration date of this general permit, then the permittee must reapply to the department for the permit to be re-issued. In order for the permit to be re-issued, the permittee should submit the appropriate application form(s) at least 180 days before the expiration of the permit if dredging activity is expected to continue past the expiration date of this general permit.

If the permittee does not apply for the renewal of this permit, this permit will automatically terminate on the expiration date. Continued discharges from a dredging project that has not been fully stabilized are prohibited beyond the expiration date; unless the permit is reissued or the permittee has filed a timely application for the reissuance of this permit.

DUTY TO COMPLY

The permittee shall comply with all conditions of this general permit. Any noncompliance with this general permit constitutes a violation of Chapter 644, Missouri Clean Water Law, and 10 CSR 20-6.200. Noncompliance may result in enforcement action, termination of this authorization, or denial of the permittee's request for renewal.

US Army Corps of Engineers ®
Kansas City District

APPENDIX B
Public Notice and Distribution List

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PUBLIC NOTICE

Permit No. 2011-1602
Issue Date: March 30, 2012
Expiration Date: April 29, 2012

US Army Corps
of Engineers
Kansas City District

30-Day Notice

JOINT PUBLIC NOTICE: This public notice is issued jointly with the Missouri Department of Natural Resources, Water Pollution Control Program. The Department of Natural Resources will use the comments to this notice in deciding whether to grant Section 401 water quality certification. Commenters are requested to furnish a copy of their comments to the Missouri Department of Natural Resources, P.O. Box 176, Jefferson City, Missouri 65102.

APPLICANT: U.S. Army Corps of Engineers – Kansas City District
700 Federal Building
601 E. 12th St.
Kansas City, Missouri 64106-2896

PROJECT LOCATION (As shown on the attached drawings): The proposed project is located on the Jameson Island Unit of the U.S. Fish and Wildlife Service, Big Muddy National Fish and Wildlife Refuge, in and along the right overbank of the Missouri River, between river mile 211.7 and 210.5, in Sections 30 and 31, Township 50 North, Range 18 West, near the town of Arrow Rock, Saline County, Missouri. Howard County, Missouri is located on the opposite river bank with the nearest town being Petersburg, Missouri. Longitude/Latitude: 39˚04’23.50” North, 92˚55’45.75” West

AUTHORITY: The project is part of the Missouri River Recovery Program (MRRP) which is authorized under the Water Resources Development Act of 2007. A component of the MRRP which addresses fish and wildlife habitat mitigation, including shallow water habitat (SWH), is the Missouri River Bank Stabilization and Navigation Fish and Wildlife Mitigation Project (Mitigation Project) which is authorized in the Water Resources Development Acts of 1986 and 1999 (Public Law 99-662). This activity is regulated by the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act (33 USC 1344).

ACTIVITY (As shown on the attached drawings): PROPOSED WORK: As part of efforts to mitigate fish and wildlife habitat losses associated with the Corps’ Missouri River Bank Stabilization and Navigation Project and in order to meet shallow water

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habitat (SWH) goals contained in the U.S. Fish and Wildlife Service's (USFWS) 2003 Amendment to the 2000 Biological Opinion (Bi-Op) on the Operation of the Missouri River Main Stem Reservoir System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System, the Corps proposes to restore SWH on the U.S. Fish and Wildlife Service, Big Muddy National Fish and Wildlife Refuge, Jameson Island Unit by constructing a chute of approximately 6,000 linear-feet, approximately 100-feet-wide, excavated to a depth of -5 foot from the Construction Reference Plain. Heavy construction equipment would be used for initial clearing/grubbing and a hydraulic dredge would then be used to excavate a 100' wide channel. Dredged material would be mixed with the existing Missouri River water and sediment load. The existing chute would be extended approximately 6,000 linear-feet to the west where another outlet to the Missouri River would be constructed. The existing chute outlet would be diverted with a closure structure constructed with clean rock riprap to +5 CRP. The area between the diversion and the river would serve as backwater habitat. The chute alignment would be cleared using heavy construction equipment with woody vegetation and 3-4 feet of earthen material stockpiled on the outer limits of the cleared zone. Earthen material would be excavated using a hydraulic dredge. Approximately 420,000 cubic yards of dredged earthen material would be pumped as slurry mixture of water and sediment and placed into the Missouri River in a location and manner that it would be integrated into the existing bedload. Through time and dependant on river levels the chute would be expected to widen and deepen and approximately 547,000 cubic yards of additional earthen material and an undetermined amount of woody debris would be integrated through natural river processes into the Missouri River bedload. This process would continue until a balance of flow and chute width is reached as limited by flow control structures, and flow of sediment in versus out would be approximately balanced. Woody debris entering the river as the channel widened and meandered would provide additional fish and wildlife habitat. In addition, during high flows, river levels would be expected to overtop the channel block and flush accumulated sediment from the backwater area. This would result in approximately 16.77acres of SWH (13.77-acre chute and 3-acre backwater) at completion of construction which would eventually be expected to develop through natural river processes to approximately 30 acres of SWH (27-acre chute and 3 acre backwater).

WETLANDS/AQUATIC HABITAT: The proposed project would require the clearing of approximately 34.4 acres of riparian timber. Based on National Wetlands Inventory maps this area includes a total of 5.0 acres of wetlands (2.25 freshwater emergent marsh, 1.84 acre freshwater forested/shrub wetland, 0.89 freshwater pond) that would be impacted at completion of construction. At full chute development that area would be expected to extend to a total of 8.9 acres of wetland (3.74 acres freshwater emergent marsh, 3.45 acres freshwater forested/shrub wetland, 1.75 acres freshwater pond). The extent of these areas was verified as part of a preliminary jurisdictional determination through a review of NWI maps, soil surveys, topographic maps, aerial photographs and field survey of the proposed alignment. Approximately 27 acres of the 34.4 acre cleared area would be developed into SWH. In addition, earthen material excavated during chute construction would be placed into the Missouri River in a location and manner that it would be integrated into the Missouri River bedload and not expected to permanently

change the bed contour or convert an area to a non-aquatic site. Construction would restore the natural process of erosion, cutting, filling and meandering along the length of the chute. The proposed project would result in minor long term adverse impacts to wetlands and in minor temporary adverse construction related impacts to vegetation, wetlands, recreation and fish and wildlife resources. These impacts would occur in the immediate project area and areas immediately adjacent. These minor long term and minor temporary adverse construction related impacts would be greatly outweighed by the long term beneficial effects to the aquatic ecosystem resulting from the proposed SWH restoration project.

APPLICANT'S STATEMENT OF AVOIDANCE, MINIMIZATION, AND COMPENSATORY MITIGATION FOR UNAVOIDABLE IMPACTS TO AQUATIC RESOURCES: The proposed project has been designed to incorporate all practicable measures to minimize and/or avoid adverse impacts to aquatic resources. As a critical component of the Corps efforts to implement the Missouri River Bank Stabilization and Navigation Project Fish and Wildlife Mitigation Project and to comply with the U.S. Fish and Wildlife Service's (USFWS) 2003 Amendment to the 2000 Biological Opinion (Bi-Op) on the Operation of the Missouri River Main Stem Reservoir System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System, the overall project goal is to mitigate project impacts to fish and wildlife habitat by restoring SWH for the benefit of the Missouri River aquatic ecosystem, including the Federally-listed endangered pallid sturgeon. As such, the Corps has made a preliminary determination that no compensatory mitigation measures are warranted or proposed.

ADDITIONAL INFORMATION: Additional information about this application may be obtained by contacting Mr. David R. Hoover, Biologist, U.S Army Corps of Engineers, Kansas City District, ATTN: Environmental Resources Section, Planning Branch, 601 East 12th Street, Kansas City, Missouri 64106, by email at david.r.hoover@usace.army.mil, or by telephone at (816)389-3497. All comments to this public notice should be directed to the above address.

NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) OF 1968, as amended: The Corps prepared a *Feasibility Report and Environmental Impact Statement* in 1981 on the original Mitigation Project of 48,100 acres. After Congress modified the Mitigation Project by WRDA99, the Corps initiated a *Supplemental Environmental Impact Statement* (SEIS) in September 2001 for the additional 118,650 acres and including 7,000 to 20,000 acres of SWH. The SEIS was completed in early 2003 and the *Record* of *Decision* (ROD) was signed in June 2003. The Corps has prepared a DRAFT Project Implementation Report with Integrated Environmental Assessment and Section 404(b)(1) Evaluation. The Recommended Alternative described in this PIR includes site specific measures that would be used to implement the Selected Alternative described in the Corps' 1981 *Feasibility Report and Environmental Impact Statement* in

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1981 on the original Mitigation Project and the 2003 *Supplemental Environmental Impact Statement* (2003 SEIS) on the Mitigation Project as modified by WRDA99. This document is available online at:

http://www.nwk.usace.army.mil/regulatory/CurrentPN/currentnotices.htm

The Corps has made a preliminary determination that the proposed project would not result in significant degradation of the human environment and therefore the proposed project would support a Finding of No Significant Impact (FONSI). The Corps will utilize comments received in response to this Public Notice to complete our evaluation of the project for compliance with the requirements of NEPA, and other Federal, state, and local regulations, including this review for project compliance with the requirements of Section 404 of the Clean Water Act. The Corps has made a preliminary determination that the proposed project would not be contrary to the public interest and is in compliance with the Section 404(b)(1) Guidelines. The DRAFT Section 404(b)(1) Evaluation is included in the Project Implementation Report with Integrated Environmental Assessment and Section 404(b)(1) Evaluation.

CULTURAL RESOURCES: The proposed project has been reviewed in compliance with the National Historic Preservation Act of 1966 (Public Law 89-665). Background research that consisted of a review of the National Register of Historic Places (NRHP), a site records search, and a review of historic channel and shipwreck maps was conducted for the project. No historic properties listed in the NRHP were identified in the immediate project area. A search of records with the Missouri State Historic Preservation Officer (SHPO) identified no previously recorded archeological sites or historic structures in the immediate project area. A number of shipwrecks including the Sam Gaty (1867), the New Sam Gaty (1868), Plow Boy No.2 (1877), Tom Rodgers (1887), and Benton No.2 (1895) are mapped in close proximity to the proposed project area. An accreted land study conducted by the Corps found that most of the project area consists of accreted land, with most of the accretion occurring since 1879. The proposed project alignment was developed to avoid mapped areas of non-accreted land and mapped shipwreck locations. Because the project area consists of recently accreted land and no archeological sites, historic structures, or shipwrecks have been recorded in the project area, it is unlikely that the project would impact historic properties or sites that may be eligible for inclusion on the NRHP. Therefore, we have determined that an archeological survey of the project area is not warranted.

The Arrow Rock National Historic Landmark, listed on the National Register of Historic Places is located just west of the project area. In order to avoid impacts to the NHL the Corps has committed to move heavy construction equipment to and from the site by floating plant.

The Corps provided the SHPO with a determination of no historic properties affected by the proposed project and in a response email dated 21 March 2012 the SHPO provided concurrence with the Corps' determination that there would be "no historic properties

affected" by the proposed project. In addition, the Corps will take into consideration any information from affiliated Native American tribes or the public on any sites or traditional cultural properties that may be of concern.

ENDANGERED SPECIES: A primary goal of the proposed project is to meet SWH targets contained in the U.S. Fish and Wildlife Service's (USFWS) 2003 Amendment to the 2000 Biological Opinion (Bi-Op) on the Operation of the Missouri River Main Stem Reservoir System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System.

In compliance with the Endangered Species Act, a preliminary determination has been made that the described work will not affect species designated as threatened or endangered or adversely affect critical habitat. In order to complete our evaluation of this activity, comments are solicited from the U.S. Fish and Wildlife Service and other interested agencies and individuals.

FLOODPLAINS: This activity is being reviewed in accordance with Executive Order 11988, Floodplain Management, which discourages direct or indirect support of floodplain development whenever there is a practicable alternative. By this public notice, comments are requested from individuals and agencies that believe the described work will adversely impact the floodplain.

WATER QUALITY CERTIFICATION: Section 401 of the Clean Water Act (33 USC 1341) requires that all discharges of dredged or fill material must be certified by the appropriate state agency as complying with applicable effluent limitations and water quality standards. The discharge must be certified before a Department of the Army permit can be issued. Certification, if issued, expresses the state's opinion that the discharge will not violate applicable water quality standards.

PUBLIC INTEREST REVIEW: The decision to issue a permit will be based on an evaluation of the probable impact including the cumulative impacts of the proposed activity on the public interest. That decision will reflect the national concern for both protection and utilization of important resources. The benefits which reasonably may be expected to accrue from the proposal must be balanced against its reasonably foreseeable detriments. All factors which may be relevant to the proposal will be considered including the cumulative effects thereof; among those are conservation, economics, esthetics, general environmental concerns, wetlands, cultural values, fish and wildlife values, flood hazards, floodplain values, land use, navigation, shoreline erosion and accretion, recreation, water supply and conservation, water quality, energy needs, safety, food and fiber production, mineral needs and, in general, the needs and welfare of the people. The evaluation of the impact of the activity on the public interest will include application of the guidelines promulgated by the Administrator, Environmental Protection Agency under authority of Section 404(b) of the Clean Water Act (33 USC 1344). The Corps of Engineers is soliciting comments from the public; Federal, state, and local agencies and officials; Indian Tribes; and other interested parties in order to consider and evaluate the impacts of this proposed activity. Any comments received will

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be considered by the Corps of Engineers to determine whether to issue, modify, condition or deny a permit for this proposal. To make this decision, comments are used to assess impacts on endangered species, historic properties, water quality, general environmental effects, and the other public interest factors listed above.

Comments are used in preparation of an Environmental Assessment and/or an Environmental Impact Statement pursuant to the National Environmental Policy Act. Comments are also used to determine the need for a public hearing and to determine the overall public interest of the proposed activity.

COMMENTS: This notice is provided to outline details of the above-described activity so this District may consider all pertinent comments prior to determining if issuance of a permit would be in the public interest. Any interested party is invited to submit to this office written facts or objections relative to the activity on or before the public notice expiration date. Comments both favorable and unfavorable will be accepted and made a part of the record and will receive full consideration in determining whether it would be in the public interest to issue the Department of the Army permit. Copies of all comments, including names and addresses of commenters, may be provided to the applicant. Comments should be mailed to the address shown on page 2 of this public notice and include ATTN: PM-PR (Hoover).

PUBLIC HEARING: Any person may request, in writing, prior to the expiration date of this public notice, that a public hearing be held to consider this application. Such requests shall state, with particularity, the reasons for holding a public hearing.

PUBLIC MEETING: The Corps has scheduled an open forum Public Information Meeting on the Jameson Island Unit SWH Restoration Project for 6:00 – 8:00 p.m. on Tuesday, April 17, 2012 at the Arrow Rock State Historic Site Visitor Center. This meeting will provide an opportunity for interested stakeholders to receive additional information on the project and provide input for use in completion of the FINAL Project Implementation Report.

NOTE: This public notice is posted on the Kansas City District Regulatory web page and can be viewed at the following address:

http://www.nwk.usace.army.mil/regulatory/CurrentPN/currentnotices.htm

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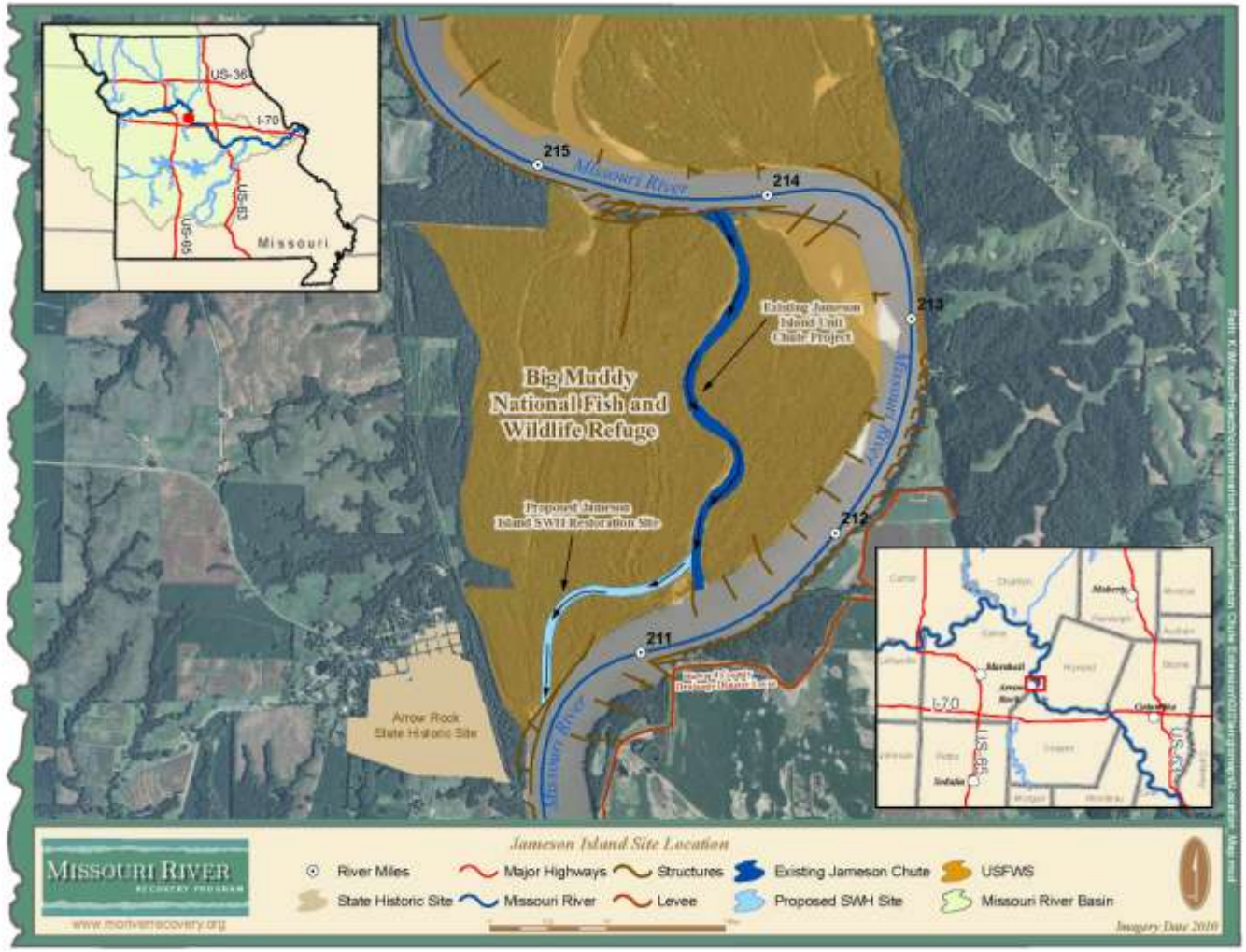
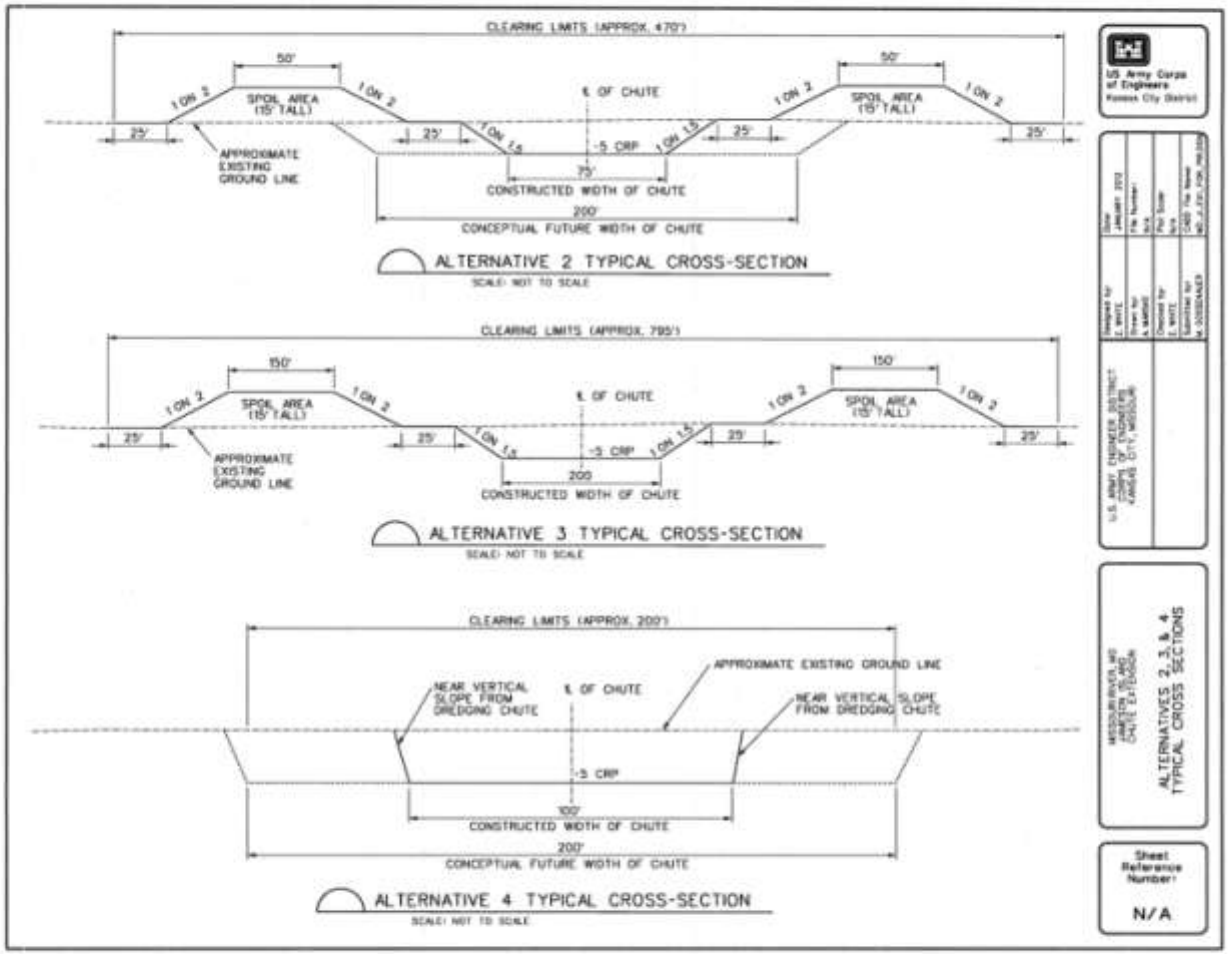


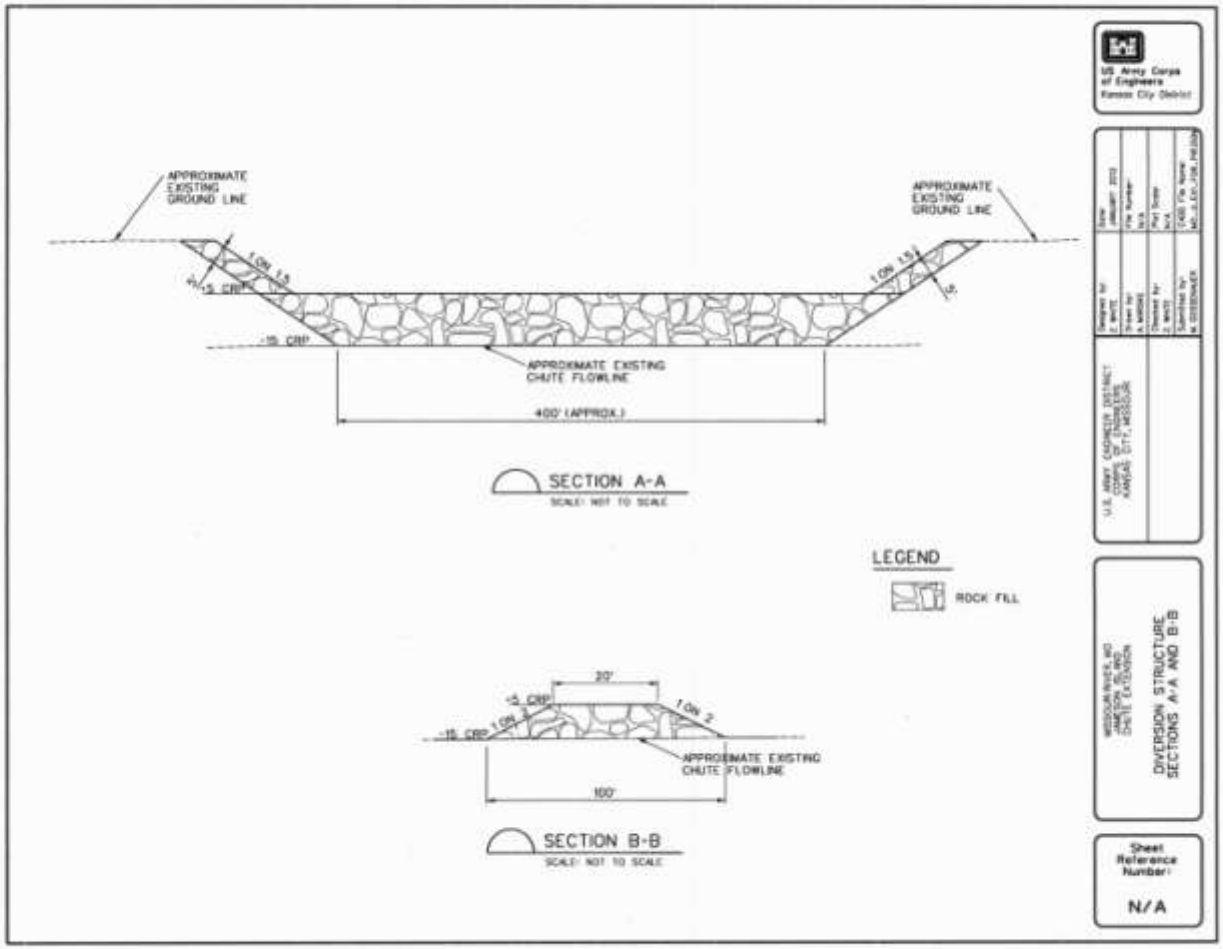
PROJECT LOCATION
Jameson Island Unit, USFWS Big Muddy National
Fish & Wildlife Refuge, Missouri River, RDB,
mile 211.7-210.5, Sections 30 & 31, Township 50 North,
Range 18 West, near the Town of Arrow Rock,
Saline County, Missouri

APPLICATION NO. 2011-1602
U.S. Army Corps of Engineers
-Kansas City District
Shallow Water Habitat Restoration
Missouri River and Adjacent Wetlands
Saline County, MO
SHEET 1 of 3
Dated 30 March 2012



ALTERNATIVE 4 - PROPOSED CHUTE X-SECTION

APPLICATION NO. 2011-1602
U.S. Army Corps of Engineers
-Kansas City District
Shallow Water Habitat Restoration
Missouri River and Adjacent Wetlands
Saline County, MO
SHEET 2 of 3
Dated 30 March 2012



PROPOSED DIVERSION STRUCTURE

APPLICATION NO. 2011-1602
U.S. Army Corps of Engineers
-Kansas City District
Shallow Water Habitat Restoration
Missouri River and Adjacent Wetlands
Saline County, MO
SHEET 3 of 3
Dated 30 March 2012

US Army Corps of Engineers ®
Kansas City District

APPENDIX C
Public Notice / Public Meeting Comments

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Missouri River Recovery Program **March 2012**
Missouri River Bank Stabilization and Navigation
Fish and Wildlife Mitigation Project

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US Army Corps of Engineers ®
Kansas City District

APPENDIX D
Cultural Resources

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Missouri River Recovery Program
Missouri River Bank Stabilization and Navigation
Fish and Wildlife Mitigation Project

March 2012

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Hoover, David R NWK

From: Deel, Judith [judith.deel@dnr.mo.gov]
Sent: Wednesday, March 21, 2012 3:11 PM
To: Meade, Timothy M NWK
Cc: Hoover, David R NWK
Subject: RE: Jameson Island SHPO coordination (UNCLASSIFIED)

SHPO has reviewed the information provided concerning the Jameson Island Chute project, and concur that there will be "no historic properties affected". We have no objections to the initiation of project related activities.

Judith Deel
Compliance Coordinator
State Historic Preservation Office
P.O. Box 176
Jefferson City, Missouri 65102
judith.deel@dnr.mo.gov
573/751-7862 (phone)

US Army Corps of Engineers ®
Kansas City District

APPENDIX E
Water Quality Field Sampling Plan

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Missouri River Recovery Program **March 2012**
Missouri River Bank Stabilization and Navigation
Fish and Wildlife Mitigation Project

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FIELD SAMPLING PLAN

for

2011 Jameson Island Site Characterization
Missouri River Mitigation Site Project

Missouri River Recovery Program – Integrated Science Program

Prepared By:

Missouri River Recovery Program (MRRP)
Integrated Science Program
Kansas City District Water Quality Program
U.S. Army Corps of Engineers – Kansas City District

1 March 2011

SIGNED

USACE – Limnologist
Todd Gemeinhardt
CENWK-PM-PR-W

Date

SIGNED

USACE – Environmental Manager
Andy Gosnell
CENWK-ED-ED

Date

SIGNED

USACE – Acting Chief, Environmental Resources Section
David Hoover
CENWK-PM-PR

Date

Distribution List:

U.S. Army Corps of Engineers – Kansas City District (NWK)

Chance Bitner, PM-C
Kathy Older – ED-GG

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1. PROJECT DESCRIPTION

1.1. BACKGROUND INFORMATION

The U.S. Army Corps of Engineers (USACE) is proposing a project to create shallow-water habitat along the Missouri River at Jameson Island (Big Muddy National Wildlife Refuge) as part of the Missouri River Recovery Program (MRRP). The project consists of the creation of shallow water habitat for the benefit of native large river fish, including the pallid sturgeon (*Scaphirhynchus albus*), and provides connectivity with the Missouri River and its floodplain. The project is also designed to help mitigate for the loss of habitat that resulted from the construction, operation, and maintenance of the Missouri River Bank Stabilization and Navigation Project (BSNP). The proposed project involves the construction an individual pilot chute approximately 6000 feet in length. The chute will be constructed by excavating a pilot channel approximately 75 ft wide with a 2H :1V side-slope. Flow will be allowed into the pilot channels to naturally develop sinuosity and shallow water habitat diversity. Excavated material from construction will be side-cast on-site into spoil piles on both sides of the chutes. It is believed the excavated alluvial material will be primarily sand with some silts and clays.

1.1.1. Project Location

The project site is located along the Missouri River in Saline County, Missouri (see Figure 1). This project is located along the right descending bank of the Missouri River between rivers miles (RM's) 210 - 214. The site consists of approximately 1,871 acres of land on the western floodplain. This land is owned by the US Fish and Wildilfe Service (USFWS) and is managed as part of the Big Muddy National Wildlife Refuge System. The site is located approximately west of Arrow Rock, Missouri in section 31.

Vehicle access is made by driving taking Main Street through Arrow Rock to Godsey's Diggings, the gravel road behind the Lyceum Theater to the refuge parking lot and information kiosk. Boat access is made via the De Bourgmont Boat Ramp in Cooper County, MO. To reach the ramp, travel on I-70 to Mo Highway 41. Take Highway 41 North approximately 1.5 miles to the ramp. Upon launching, proceed down the Lamine River to where it enters the Missouri River (RM 202.5). Proceed up river (west then north) approximately 12 miles to the river site (JA-W1).

1.1.2. Proposed Disposal Plan

Alluvial material will be excavated and side-cast onto spoil piles on both sides of the chute. Upon completion of construction, the pilot chute will be connected to the Missouri River and will be subject to the natural forces of the river.

1.1.3. Permitting Requirements

A National Pollution Discharge Elimination System (NPDES) general permit is required from the Missouri Department of Natural Resources (MDNR). In addition to the general permit, an associated stormwater pollution prevention plan (SWPPP) is required. These permits are required prior to Section 401 certification, which must be obtained from MDNR. This monitoring project plan was developed in support of the proposed project for Section 401 Certification.

1.2. PROJECT/TASK ORGANIZATION AND RESPONSIBILITIES

The USACE's Kansas City District's Water Quality Program and Geology Section staff will conduct the site characterization -- sediment and water quality data -- to facilitate review of the proposed project for Section 401 Water Quality Certification.

Staff Responsibilities and Contacts for Sampling:
Sample Collection and Coordination: Todd Gemeinhardt and Andy Gosnell
Laboratory Analysis: ARDL, Inc.

1.3. DATA QUALITY OBJECTIVES

The data collected through this monitoring project will be used by the State of Missouri for use in reviewing the proposed Benedictine Bottoms mitigation project for Section 401 Water Quality Certification.

2. DATA COLLECTION APPROACH

There are no known contaminants of concern at the Benedictine Bottoms mitigation project site.

2.1. DATA COLLECTION DESIGN

Soil samples will be collected from 6 locations (JA-S1 through JA-S6) for laboratory analysis and elutriate sample preparation / analysis. The preparation and analysis of elutriate samples are a means of quantifying the potential impacts to water column quality. Samples of Missouri River water will be collected at one site (JA-W1) for water quality analysis in the proposed project area. The approximate sample locations are shown in Figure 2. The location of the sampled sites will be determined with a GPS unit in the field during the site recon phase or when samples are collected. The sample numbering is shown in the Field Data Sheet in Attachment 1.

2.2. MEASUREMENT AND SAMPLING METHODS

2.2.1. River Water Samples

Missouri River water samples will be collected from one upstream location, JA-W1, at the project area (RM 214.5). The samples will be collected in accordance with this FSP or Standard Operating Procedures (SOP) developed by the NWO Water Quality Unit (USACE 2003).

A transect will be established at the river sampling location. Surface samples (0.1 – 0.5m) will be collected at four evenly distributed locations across the transect location by dividing the river into four equal increments. Each of the samples will be analyzed individually by the contract laboratory. In addition to the four individual surface samples collected for this project (1 transects x 4 grabs/transect), one duplicate sample will be collected for laboratory analysis. Sample volume requirements, holding times, and preservation will be specified by the contract laboratory.

In addition to collecting water samples for laboratory analyses, river water will be collected for the preparation of elutriate sample analyses (see Section 2.2.3). This water will be collected from JA-S1 (upstream). The laboratory requires 4 L of receiving water for each 1 L of sediment to ensure sufficient volume to prepare the elutriate samples for analysis. Assuming 1 L of sediment will be collected from each of the 6 locations plus 1 duplicate, 28 L of river water will be collected from Site JA-W1. Approximately 7 L of river water will be collected from each

transect location to fulfill this requirement. The 7 liter sub-samples will be combined evenly into four 5-gallon or equivalent large volume containers for use in the elutriate analyses.

At the time river water samples are collected, ambient field measurements will be recorded for temperature, dissolved oxygen, pH, conductivity and turbidity. These measurements will be obtained with a HydroLab DataSonde 5 and Surveyor 4 data logger. A plastic bucket will be used to collect a near-surface water sample at each transect point. The instrument will then be immediately placed in the plastic bucket and the measurements taken. Measurements will be appropriately recorded on a field sheet (Attachment 1). The bucket will be thoroughly rinsed with river water at each sample point prior to filling for measurement to prevent cross-contamination interference.

Discrete water samples for chemical analysis will be collected with a NASCO Swing Sampler. A near-surface sample will be collected by dunking the sampler into the river at a depth of 0.1 – 0.5 m. Water will be poured out of the collection bottle into appropriate sample containers. Samples will be stored on ice in coolers immediately after collection. Samples collected for dissolved metals analysis will be placed initially in unpreserved bottles. After returning to shore, the dissolved metal samples will be filtered through 0.45-micron filters and placed into appropriate pre-preserved bottles. All samples will be packed in coolers with ice for shipment to the laboratory. The water samples will be analyzed for parameters listed in Table 1.

2.2.2. Sediment Samples

Sediment borings will be collected along the chute alignments using a hand auger. All machinery and down-hole sampling equipment will be washed prior to entering and exiting the site. Waste generated from the borings is not considered hazardous and will not need to be containerized. A decontamination pad is not required for this project and wash water will not be containerized.

Sediment samples will be collected at 6 locations (JA -S1 through JA-S6) for laboratory analysis and elutriate sample preparation / analysis. The location of the borings will be at approximately 1000-ft intervals along the pilot chute alignment. Continuous sample cores will be collected using the hand auger. Offset borings will be advanced as necessary to obtain enough material to create a composite sample of each borehole with sufficient unsaturated volume to meet laboratory requirements. The borings will be advanced to the depth of approximately 6 feet.

One composite sample will be collected from each location (JA-S1 through JA-S6) and analyzed for the parameters in Table 1. New pre-cleaned buckets or large aluminum baking pans and tools (e.g., Teflon trowels, stainless steel spoons) will be used to prepare each composite sample. After each coring, the sediment from the Macro-Core sampler will be deposited into the collection bucket or pan. When all cores from one site have been collected in the bucket, the contents will be homogenized and transferred to glass jars provided by the laboratory for each analysis. The sample label will be placed on the jar prior to filling with sample. The collected sediment samples will be placed into a shipping cooler with ice for shipment to the laboratory. The coring tools (i.e., cutting shoes, rods) will be cleaned with an Alconox / tap water solution between sample locations and rinsed with distilled water.

At one locations, JA-S1, discrete samples will be collected at 3 foot intervals to the depth of 6 feet. The discrete soil samples will be placed directly into sample jars provided by the laboratory.

In addition to the composite and discrete samples described above, one duplicate composite sample will be collected for laboratory analysis. Sample volume requirements will be specified by the contracted laboratory.

Each borehole will be properly abandoned in accordance with MODNR well abandonment requirements upon completion of sampling activities. The borehole decommissioning standards are provided by Title 10, Division 23, Chapter 3 of the Missouri Code of State Regulations (10 CSR 23-3.110).the KDHE's well construction rules K.A.R. 28-30-1 through 28-30-207.

2.2.3. Elutriate Samples

Elutriate samples will be prepared by the laboratory in accordance with the "Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. – Testing Manual: Inland Testing Manual" (USEPA and USACE, 1998). The elutriate sample will be prepared by using river water from the project area and composite sediment samples collected along the chute alignment. Nineteen elutriate samples will be analyzed for the parameters indentified in Table 1. In addition, two duplicate samples will be collected for laboratory analysis.

The elutriate is prepared by sub sampling approximately 1 L of the dredged material from the well-mixed original sample. The dredged material and unfiltered water are then combined in a sediment-to-water ratio of 1:4 on a volume basis at room temperature (22 ± 2°C). This is best accomplished by volumetric displacement. After the correct ratio is achieved, the mixture is stirred vigorously for 30 min with a mechanical or magnetic stirrer. At 10 min intervals, the mixture is also stirred manually to ensure complete mixing. After the 30 min mixing period, the mixture is allowed to settle for 1 h. The supernatant is then siphoned off without disturbing the settled material, and centrifuged to remove particulates prior to chemical analysis (approximately 2,000 rpm for 30 min, until visually clear).

2.3. Sample Handling, Custody, and Transport

The collected samples will be prepared by staff and shipped via FedEx to the contracted laboratory (ARDL, Inc.) for analysis. A chain-of-custody record will be completed and submitted with the samples delivered to the laboratory (Attachment 2). All samples – water and sediment – will be stored in coolers with ice prior to shipment.

2.4. Parameters to be Measured and Analyzed

The parameters that will be measured or analyzed for the different types of samples are listed in Table 1. Table 2 lists the sampling bottles to be used, holding times, and preservatives for each of the parameters.

2.5. Analytical Methods

Table 1 lists the methods that will be used by the contract lab for sample analyses.

A maximum laboratory turn-around time of 20 days is required to ensure the USACE can stay on schedule regarding the implementation of the restoration project.

2.6. Quality Control

Several types of quality control (QC) will be collected for analysis and the results will be used to assess sampling and analytical precision. These samples will include field duplicates and trip blanks. All field measurements and samples will be collected in accordance with SOPs developed by the USACE's Water Quality Program.

The following table summarizes the type and frequency of these samples to be collected:

Field QA and QC Samples		
QA / QC Sample	**Frequency**	**Analysis Location**
Field Duplicates	1/10 (10 %)	Contract Lab
Trip Blank	1 per day	Contract Lab

3. DATA MANAGEMENT AND REPORTING

All water quality measurements and analyses will be verified, validated, and compiled into an Excel spreadsheet. To assess the potential for water quality impacts from this project, elutriate water concentrations will be compared to upstream concentrations measured at location WC-W1. Soil analytical results will be compared to target values identified in Table 3.

4. PROJECTED COSTS FOR FIELD COLLECTION AND LABORATORY ANALYSIS OF SAMPLES

	Itemized Costs	**Total Cost**
Field / Office		
PM-PR G5H4620 G5H4621	 $ 5,000 – labor $ 5,000 – labor	$10,000
ED-E G5L0340 G5L0320	 $ 5,000 - labor $	$ 5,000
CT – H	$	$
ED-GG G5L0420 G5L0421 G5L00000 G5L00000	 $ $ $ $	$
Laboratory		
Contract Lab	$25,000 - analytical $ 1000 - shipping	$26,000
Total Cost		**$41,000**

5. REFERENCES

MacDonald, D.D., Ingersoll, C.G., and Berger, A. 2000. Development and evaluation of concensus-based sediment quality guidelines for freshwater ecosystems. Archives of Environmental Contamination and Toxicology 39:20-31.

Tidball, R.R. 1984. Geochemical survey of Missouri. USGS Profession Paper 954H.

USEPA and USACE. 1998. Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. - Test Manual: Inland Testing Manual. EPA-823-B-98-004, February 1998. U.S. Environmental Protection Agency, Office of Water. Department of Army, U.S. Army Corps of Engineers. Washington, D.C

USACE. 2003. Collection of Surface Water Samples, SOP Number: WQ-21101.

Water Quality Unit, Water Control and Water Quality Section, Hydrologic Engineering Branch, Engineering Division, Omaha District, USACE.

Table 1. Parameters to be measured and analyzed.

Parameter	Method	Samples to be Analyzed [2]		
		Sediment	River Water	Standard Elutriate Water
Field Measurements:				
Water Temperature (°C)	HydroLab [1]		4	
pH (S.U)	HydroLab [1]		4	
Dissolved Oxygen (mg/l)	HydroLab [1]		4	
Conductivity (umhos/cm)	HydroLab [1]		4	
Turbidity (FTU)	Hydrolab [1]		4	
Laboratory Analysis:				
Total Suspended Solids (mg/l)	EPA 160.2	10	5	8
Ammonia as N, Total (mg/l)	EPA 350.1 SM 4500-NH3-B,C	10	5	8
Nitrogen – Total Kjeldahl Nitrogen (mg/l)	EPA 351	10	5	8
Nitrogen – Nitrate / Nitrite as N (mg/l)	EPA 353 / 354	10	5	8
Phosphorus – Total (mg/l)	EPA 365.4 or SM 4500-P	10	5	8
Phosphorus – Soluble Reactive (orthophosphorus)	SM 4500-P / EPA 365	10	5	8
Carbonaceous Biochemical Oxygen Demand –CBOD (mg/l)	5210.B	10	5	8
Total Organic Carbon – TOC (mg/l)	EPA - 365.1	10	5	8
Metals – Total Cadmium, Copper, Chromium, Lead, Nickel, Zinc	EPA – 6010C	10		8
Metals – Dissolved Cadmium, Copper, Chromium, Lead, Nickel, Zinc	EPA - 6010B		5	
Pesticides – Chlordane, Dieldrin, DDt and metabolites	846 8081	10	5	8

[1] Hydrolab or equivalent water quality meter

[2] Includes 10% field duplicate:
Sediment – 6 composite, 2 grab, 1 duplicate, 1 ms
Water – 4 grab, 1 duplicate
Elutriate – 6 locations, 1 duplicate, 1 ms

Table 2. Sample containers, required volumes, holding times, and preservatives.

Analyte	Method	Container	Holding Time	Min. Volume	Preservation
Sediment Samples					
Particle Size	sieve	Baggie	28 days	1 Quart	4C
Ammonia	350.1	Glass	28 days	270 mL	4C
Nitrogen – Total Kjeldahl Nitrogen (mg/kg)	EPA 351	Glass	28 days	270 mL	4C
Nitrogen – Nitrate / Nitrite as N (mg/kg)	EPA 353 / 354	Glass	28 days	270 mL	4C
Phosphorus – Total (mg/kg)	EPA 365.2 or SM 4500-P	Glass	28 days	270 mL	4C
Phosphorus – Soluble Reactive (orthophosphorus)	SM 4500-P / EPA 365	Glass	48 hrs.	270 mL	4C
Pesticides (ug/g) – Chlordane, Dieldrin, DDT&Metabollites	SW 846 8081	Glass	14 days	270 mL	4C
Metals – Total Cadmium, Copper, Chromium, Lead, Nickel, Zinc	6010C	Glass	180 days	270 ml	4C
Elutriate Sediment	N/A	Glass		1 gallon water + 1 L sediment	
Water Samples					
Ammonia as N, Total (mg/l)	EPA 350.1 SM 4500-NH3-B,C	Poly	28 days	1L	Sulfuric Acid
Nitrogen – Total Kjeldahl Nitrogen (mg/l)	EPA 351	Poly	28 days	1L	Sulfuric Acid
Nitrogen – Nitrate / Nitrite as N (mg/l)	EPA 353 / 354	Poly	28 days	1L	Sulfuric Acid
Phosphorus – Total (mg/l)	EPA 365.2 or SM 4500-P	Poly	28 days	1L	Sulfuric Acid
Phosphorus – Soluble Reactive (orthophosphorus)	SM 4500-P / EPA 365	Cubitainer	48 hrs.	1L	4C
Carbonaceous Biochemical Oxygen Demand – CBOD (mg/l)	EPA – 5210B	Cubitainer	48 hrs	1L	4C
Total Organic Carbon – TOC (mg/l)	EPA – 9060/415.1	Poly	28 days	250 mL	Sulfuric Acid
Metals – Dissolved Cadmium, Copper, Chromium, Lead, Nickel, Zinc	EPA - 6010B	Poly	6 months	1L	Nitric Acid
Pesticides – Chlordane, Dieldrin, DDt and metabolites	846 8081	Amber glass	7 days	1L	4C
Total Suspended Solids (mg/l)	EPA 160.2	Cubitainer	7 days	1L	4C
Hardness	SM2340B	Poly	6 months	1L	Nitric Acid

Table 3. Target values for laboratory analyzed chemical parameters.

Parameter	Target Values				
	MDL	PQL	Sediment	River Water	Standard Elutriate Water
Ammonia (mg-N/L or mg-N/kg)	0.021	0.2		X	
Nitrogen – Total (mg/kg or mg/L)				X	
Nitrogen – Total Kjeldahl Nitrogen (mg/kg or mg/L)	0.1	0.2		X	
Nitrogen – Nitrate / Nitrite as N (mg/kg or mg/L)	0.0083	0.05		X	
Phosphorus – Total (mg/L)	0.007	0.033	0.059 pct(2) 590 mg/L DW	X	
Phosphorus – Soluble Reactive (mg/kg or mg/L)	0.02	0.1		X	
Total Suspended Solids (mg/l)				X	X
Chemical Oxygen Demand – COD (mg/l)	6.9	20		X	X
Total Organic Carbon – TOC (mg/l)	10	100	1.25 pct(2)	X	X
Metals – Total (mg/kg)					
Cadmium	0.0055	0.25			
Chromium	0.014	1			
Copper	0.021	1.5			
Lead	0.041	0.5			
Nickel	0.026	2.5			
Zinc	0.056	2.5			
Metals – Dissolved (ug/L)					
Cadmium	0.1	5		X	See note 4
Chromium	0.38	20		X	See note 4
Copper	6.3	30		X	See note 4
Lead	0.46	10		X	See note 4
Nickel	0.59	50		X	See note 4
Zinc	2.3	50		X	See note 4
Pesticides					
Chlordade					
Dieldren					
DDT&Metabolites					

(1) concensus-based probable effect concentration (PEC) in mg/kg (MacDonald et. Al 2000)
(2) average total concentration in Missouri soils in ppm except as noted in percent (pct)(Tidball 1984).
(3) site-specific target values are being developed
(4) 10 CSR 20-7, Table A – Metals (hardness dependent)
MDL = method detection limit
PQL = practical quantitation limit, the lowest concentration standard analyzed and can be verified
DW = dry weight
Pct = percent, 1 pct = 10,000 ppm

Figure 1. Location map of the Jamson site.

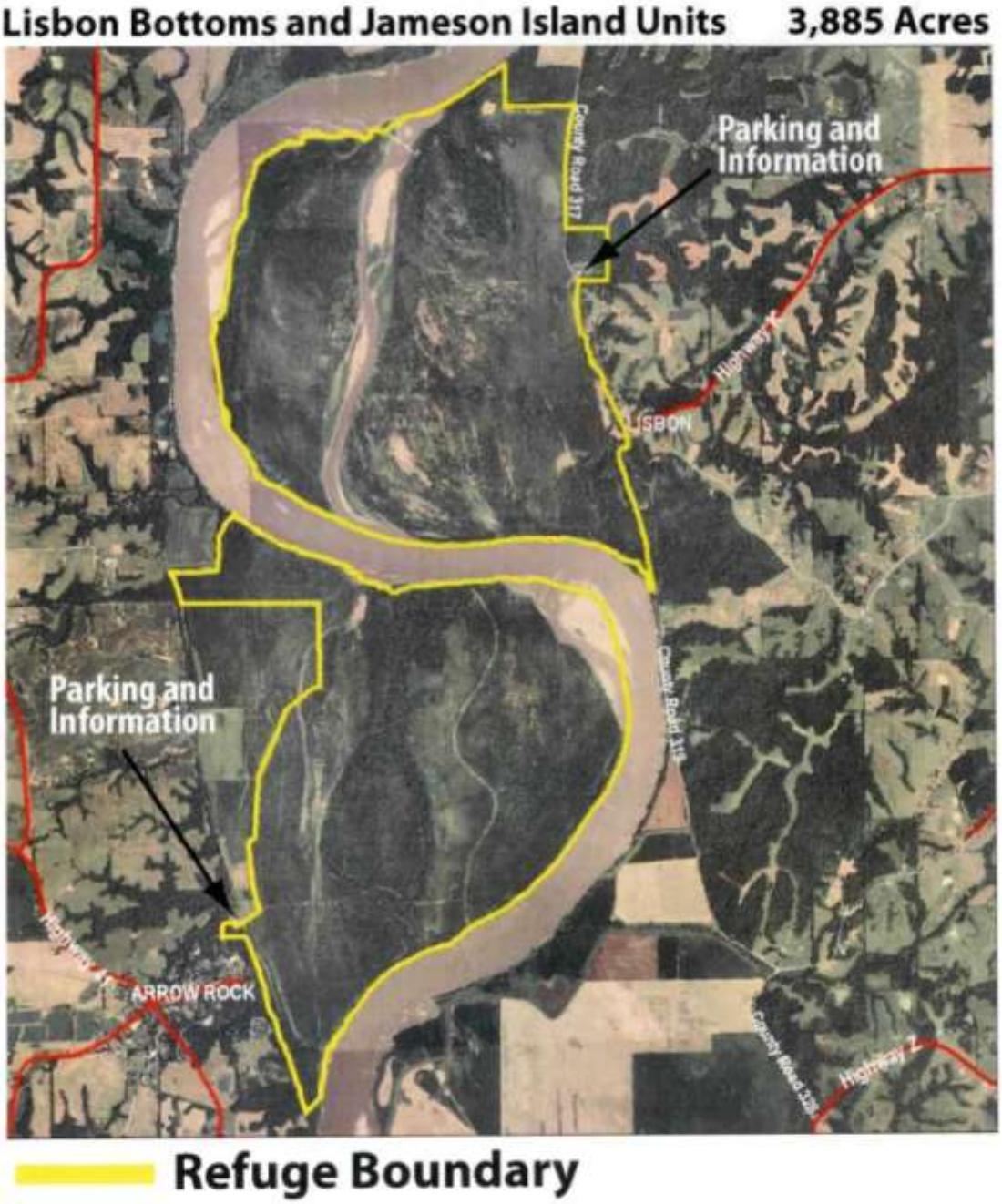

Figure 2. Location of sites to be sampled as part of the Jameson Island Mitigation project; JA-S = sediment and JA-W= water.

Attachment 1. Field Sheets for Wolf Creek Site Characterization Sampling (USACE – MRRP WQP)

FIELD DATA SHEET

Project Name: Jameson Island Site Characterization Sampling **Project Number:**

Trip Number: _____

Site Location: _____

Site Number: _____ **Date:** _____

Collectors: _____

GPS MEASUREMENTS

GPS Device Used: Garmin GPSMAP 76

Site JA-S1:	Latitude: 39 04 27.63368	Longitude: -92 55 29.50955
Site JA-S2:	Latitude: 39 04 22.69679	Longitude: -92 55 40.67753
Site JA-S3:	Latitude: 39 04 23.69322	Longitude: -92 55 53.36150
Site JA-S4:	Latitude: 39 04 18.75534	Longitude: -92 56 03.89461
Site JA-S5:	Latitude: 39 04 08.86930	Longitude: -92 56 07.20167
Site JA-S6:	Latitude: 39 03 58.98156	Longitude: -92 56 07.46437
Site JA-W1:	Latitude: _____	Longitude: _____

SEDIMENT & WATER SAMPLE COLLECTIONS

Sample Type	Sample ID	Sampled Depth	Collection Time	Sampling Method
Soil Sample	JA – S1			Composite Core
Soil Sample	JA – S2			Composite Core
Soil Sample	JA – S3			Composite Core
Soil Sample	JA – S4			Composite Core
Soil Sample	JA –S5			Composite Core
Soil Sample	JA – S6			Composite Core Discrete (3 ft interval)

AMBIENT WATER QUALITY MEASUREMENTS

Site	Time	Temp (°C)	D.O. (mg/l)	pH (S.U.)	Cond. (umho/cm)	Turbidity (NTU)
JA – W1a						
JA – W1b						
JA – W1c						
JA – W1d						
JA – W1e Replicate						

COMMENTS:

Attachment 2. Chain-of-custody form. (U.S. Army Corps of Engineers – Kansas City District – Water Quality Program).

Proj NO. USACE – 10	Proj Name:												
Samplers:													
Station	Date	Time	Comp	Grab	Station Location	No of Containers							Remarks

Relinquished by: (signature)	Date	Time	Received by: (Signature)	Relinquished by: (signature)	Date	Time	Received by: (Signature)
Relinquished by: (signature)	Date	Time	Received for Laboratory by: (Signature)		Date	Time	Remarks:

US Army Corps of Engineers ®
Kansas City District

APPENDIX F
Adaptive Management Strategy for Creation of Shallow Water Habitat (Preliminary DRAFT)

DRAFT

Missouri River Recovery Program **March 2012**
Missouri River Bank Stabilization and Navigation
Fish and Wildlife Mitigation Project

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Adaptive Management Strategy for Creation of Shallow Water Habitat

Preliminary Draft, version 4.4
August 29, 2011

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Note to the Reader

The following document describes an Adaptive Management Strategy for Shallow Water Habitat (SWH) developed for the Missouri River Recovery Program. This document is a joint product of the US Army Corps of Engineers (USACE) and the US Fish and Wildlife Service (USFWS). Although other groups and agencies referenced in this document have contributed to its development and may be involved in the implementation process described, this document has not necessarily been endorsed by any of these interests.

Introduction

The Missouri River Recovery Program (MRRP) responds to the 2003 Amended Biological Opinion and Bank Stabilization and Navigation Program Mitigation authority which call for implementation of habitat restoration actions, water management actions, and stocking actions to aid in the recovery of three federally-listed species (pallid sturgeon *Scaphirhynchus albus*, piping plover *Charadrius melodus*, and least tern *Sterna antillarum*), one species that has been de-listed (bald eagle *Haliaeetus leucocephalus*), and other native fish and wildlife species. The following Adaptive Management (AM) Strategy addresses one component of the MRRP, the effort to implement habitat restoration actions (i.e. shallow water habitat creation) for pallid sturgeon. This AM Strategy will be a component of a comprehensive adaptive management strategy for pallid sturgeon, piping plover, and least tern as part of the MRRP. Consistent with the MRRP AM Process Framework, this SWH component will be integrated with other strategies already developed (i.e. ESH, Intake diversion) as well as components related to flows, stocking, and other actions to inform the development of system-wide conceptual models and a comprehensive MRRP AM strategy. This AM strategy will also inform the broader Missouri River Ecosystem Restoration Plan (MRERP) currently under development.

This SWH AM strategy was developed prior to but in support of a more comprehensive AM strategy for several reasons. The high levels of complexity and uncertainty associated with SWH creation efforts and the fact that these efforts are currently underway in response to a prescriptive Biological Opinion with deadlines of completion within the next 10-15 years, warrant immediate and detailed attention be given to this aspect of the MRRP. As such, this SWH AM Strategy was developed to address the performance of these habitat restoration actions.
General hypotheses associated with SWH creation are:

- Shallow Water Habitat supports recruitment of pallid sturgeon and other native fishes by providing areas for the retention and rearing of larval, young-of-year (YOY) and small-bodied fishes.
- In doing so, SWH creation addresses potential bottlenecks to pallid sturgeon population growth related to poor survival and recruitment of larval/YOY fish.

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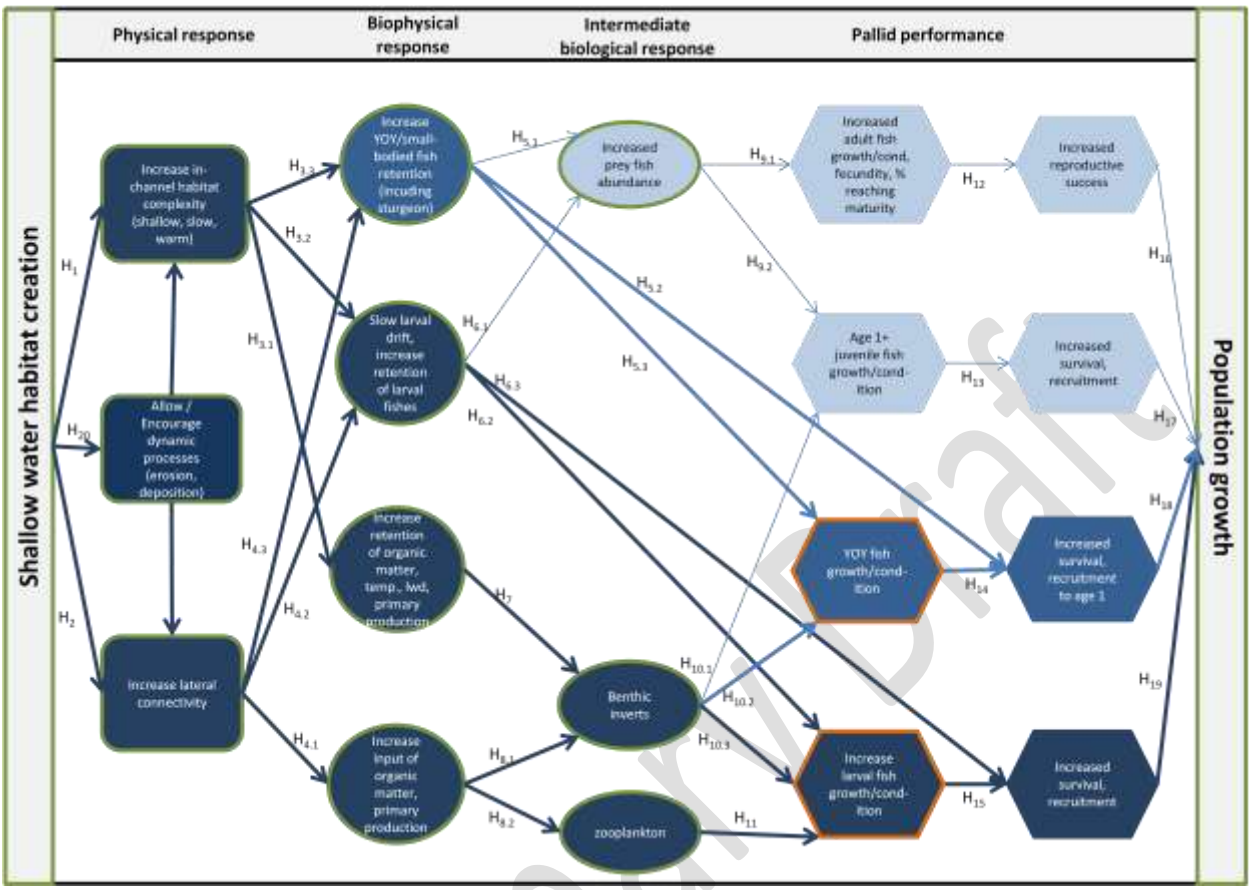

Figure A: Conceptual ecological model for shallow water habitat. (For additional explanation and hypotheses associated with this CEM, see Appendix A)

SWH creation to support pallid sturgeon and other native species is pursuant to compliance with the BiOp (USFWS 2000; 2003) and implementation of the BSNP Mitigation Project. Objectives and performance metrics were developed within the scope of the SWH sub-program with these two expressed purposes in mind. Modification of in-channel structures, widening of the main channel, and creation of chutes and backwaters are currently the primary management actions. Channel widening and chute and backwater creation can only be achieved in areas where the USACE or a cooperating government agency owns the adjacent property, so this limits the extent to which SWH can be created.

This document describes the objectives, performance metrics, management actions, monitoring, and investigations that will be undertaken to implement the SWH sub-program, track progress towards meeting objectives, resolve uncertainties related to implementation, and determine when adjustments to the sub-program are needed to better achieve stated objectives. Objectives developed for this AM Strategy focus on the anticipated physical and biological responses to SWH creation. The fundamental objectives related to population growth of pallid sturgeon and other native fishes are supported by means objectives related to the desired physical habitat changes and intermediate biological responses. These objectives and their associated performance metrics are placed in the four categories listed below and are discussed in more detail in Section 2.

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Fundamental objectives

1. System-wide responses of pallid sturgeon and other target fishes

Objective 1.1: Increase survival and recruitment of free embryos to exogenously-feeding larval pallid sturgeon
Performance Metrics: Catch rates of larval pallid sturgeon over time

Objective 1.2: Increase survival and recruitment of YOY pallid sturgeon to age 1
Performance Metrics: Catch rates of YOY and age 1 pallid sturgeon over time, pallid sturgeon population size structure changes over time, changes in growth/condition over time

Objective 1.3: Increase survival and recruitment of larval, YOY, and small-bodied big river, native fishes
Performance Metrics: Catch rates of young and small-bodied native fishes over time, changes in size structures of native fish populations over time, changes in growth/condition over time

Objective 1.4: Restore a self-sustaining population of pallid sturgeon
Performance Metrics: Pallid sturgeon population size structure changes over time, pallid sturgeon changes in abundance over time

Means objectives

2. Shallow water habitat creation and distribution

Objective 2.1: Increase abundance of shallow water habitat
Performance Metric: Acres of SWH

Objective 2.2: Distribute SWH amongst target segments
Performance Metric: Acres of SWH per target river segment

3. Physical characteristics of created shallow water habitat

Objective 3.1: Emulate depth and velocity distributions of best-achievable and/or historic habitats
Performance Metrics: Depth and velocity distributions

Objective 3.2: Emulate substrate size composition found in best-achievable habitats
Performance Metrics: Substrate size distributions

Objective 3.3: Emulate the entrainment/retention of large woody debris (LWD) found in best-achievable and/or historic habitats
Performance Metrics: Abundance of large woody debris

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Objective 3.4: Increase lateral connection of created habitat between the Median August flow level and the Ordinary High Water Mark (OHWM). Corps regulations define the term "ordinary high water mark" for purposes of the CWA lateral jurisdiction at 33 CFR 328.3(e), which states: "The term *ordinary high water mark* means that line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas."
Performance Metrics: Elevation profiles, wetted area/river stage relationships, lateral movement of bank

4. Project-scale biophysical and biological responses

Objective 4.1: Increase local abundance and species diversity of native larval, young-of-year, native cyprinids (sturgeon chub, sicklefin chub, shoal chub, blue sucker, sand shiner, Hybognathus spp.) and other target native fishes (sauger, catfishes, paddlefish, shovelnose sturgeon)
Performance Metrics: Abundance of target fishes and size classes, fish community diversity

Objective 4.2: Provide appropriate feeding/nursery areas for larval/YOY, and small-bodied fishes by creating SWHs where 1) water warms more quickly and reaches higher temperatures than currently found in main channel, 2) organic matter retention rates are higher than in the main channel, 3) terrestrial vegetation establishes in the transition zone between water line at median August flow and the Ordinary High Water Mark, and 4) benthic invertebrate abundance is higher than in the main channel
Performance Metrics: 1) water temperature, 2) total organic carbon in sediment, 3) vegetation abundance between median August flow and Ordinary High Water Mark, 4) benthic macroinvertebrate abundance and composition

Background
The geographic area for SWH creation (Ponca, NE to the mouth of the Missouri River near St. Louis, MO) corresponds with river target segments 11-15, identified for SWH restoration in the BiOp (USFWS 2000; 2003). This area includes the channelized reach of the Missouri River below the most downstream dam (Gavins Point) with the exception of the unchannelized Segment 10 (Yankton, South Dakota to Ponca, Nebraska) where SWH is already abundant. Shallow water habitat generally refers to mainstem and off-channel areas of the Missouri River where water is relatively shallow and current velocities are low. The original quantitative definition of SWH found in the U.S. Fish and Wildlife Service (USFWS) *Biological Opinion to the U. S. Army Corps of Engineers operation of the Missouri River Mainstem Reservoir System, Bank Stabilization and Navigation Project (BSNP), and Kansas River Projects* released in 2000 and amended in 2003 (USFWS 2000, 2003; hereafter, BiOp) is: *areas where water depth is greater than 0 but less than 5 feet (0-1.5m) and current velocity is less than 2ft/sec (0.6 m/s).* Further clarification was provided in the USFWS letter dated June 29, 2009 to the USACE (Appendix C). This amendment provides additional qualitative description of shallow water habitat attributes (see excerpt below).

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Shallow water habitats include side channels, backwaters, depositional sandbars detached from the bank, and low lying depositional areas adjacent to shorelines.

• Key physical components of SWH's are their dynamic nature with depositional and erosive areas, predominance of shallow depths intermixed with deeper holes and secondary side channels, lower velocities, and higher water temperatures than main channel habitats.
• Several critical questions that large-river ecology research needs to address is the issue of relative habitat size, the importance of SWH location relative to other habitat types, the influence of organic input and deposition and hydrograph influence.

Shallow water habitat benefits young and small-bodied fishes in multiple ways. It can provide areas of very slow current velocities critical for survival and retention of larval fishes (Schiemer et al. 2001). It also provides beneficial thermal conditions for larval fish by providing areas which warm quickly and attain more optimal temperatures for larval fish growth relative to the main channel (Schiemer et al. 2003). Shallow water habitats provide beneficial feeding conditions by having higher retention rates of organic matter, phytoplankton, and zooplankton, and increased primary and secondary productivity relative to the main channel (Knowlton and Jones 2000; Bunn et al. 2003; O'Neill and Thorp 2011). Availability of these nursery habitats is critical because lack of food availability for larval fishes can result in high mortality within a short time (Gisbert and Williot 2007). Shallow water habitats also reduce the risk of predation by providing refuge from predators (Schlosser 1991; Copp 1992; Ward and Sanford 1995). Although the length of time SWH is required by individual species undoubtedly varies, the commonalities at early life stages across species such as small size, poor swimming ability, vulnerability to predators, and similar feeding requirements has pointed to the importance of SWH across a wide range of fishes (Welcomme 1979; Kwak 1988; Bovee et al. 1994; Scheidegger and Bain 1995; Bowan et al. 1998; Gozlan et al. 1998; Robinson et al. 1998; Schiemer et al. 2000; Freeman et al. 2001).

In the Missouri River, SWH has been found to support high fish species richness, especially for YOY fish (Pflieger and Grace 1987; Tibbs and Galat 1997; Berry et al. 2004; Sterner et al. 2009). As a result of the BSNP, however, surface area of the river was reduced by 67% and most of this reduction resulted from eliminating relatively productive chute and slack water areas (Morris et al. 1968). Another estimate indicates a loss of over 90% of the shallow water habitat between Ponca, NE and St. Louis, MO as well as a doubling of water velocities (Funk and Robinson 1974; USFWS 2000). These changes have resulted in a river with reduced retention ability (i.e. it is very efficient at moving water, LWD, particulate organic matter, young fish, etc.), loss of the most productive habitats (Morris et al. 1968) and decreased availability of suitable fish nursery/rearing habitats. Similar findings have been reported for other river systems (Gehrke et al. 1993; Jurajda 1995; Humphries and Lake 2000; Aarts et al. 2004). It is hypothesized that lack of pallid sturgeon recruitment and reduced recruitment of other species is due to a bottleneck at the larval/YOY stage caused by loss of these nursery areas (USFWS 2000, 2003).

The Water Resources Development Act of 1986 first granted the USACE authority to undertake SWH creation as part of an effort to mitigate for the impacts of the BSNP on habitat important to native fish and wildlife in the Missouri River from Ponca, Nebraska to St. Louis, Missouri. Four years later, the pallid sturgeon was listed under the Endangered Species Act. This was followed

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by a 1990 draft Biological Opinion from the USFWS on the operations of the Missouri and Kansas River systems. In 1992, a program was initiated to propagate pallid sturgeon to circumvent the apparent reproduction/early life stage bottleneck to population growth by releasing hatchery-raised fish. Creation of shallow water habitats on the Missouri River began in the mid-1990s with the creation of Hamburg Chute as part of the congressionally-authorized BSNP Fish and Wildlife Mitigation Project. In 1995, a study of Missouri River benthic fishes, including pallid sturgeon, was initiated (Berry and Galat 2001). In 1999, the BSNP Mitigation Project was re-authorized with additional acreage added to the project (USACE 2003). Following this re-authorization, the total acreage of land authorized for acquisition and development was 166,750 acres which includes between 7,000 and 20,000 acres of SWH (USACE 2003). The total project cost for the modified Mitigation Project is estimated to range between $740,000,000 and $1,330,000,000 which includes between $500,000,000 and $900,000,000 of engineering and creation and between $45,000,000 and $80,000,000 for monitoring and evaluation (USACE 2003). Costs for the SWH portion are not broken out in the cost estimate.

Additional impetus for creation of shallow water habitats occurred with the BiOp (USFWS 2003). Under Section 7 of the Endangered Species Act of 1973 (ESA), the BiOp presents reasonable and prudent alternative (RPA) requirements for habitat restoration, creation, and acquisition related to restoration of SWH in the channelized river. The SWH restoration goal as outlined in the BiOp is to achieve an average of 20-30 acres of shallow water per mile of river. The near term targets of the MRRP were to reach 10% (2000 acres) of the SWH goal by 2005 and 30% (5,870 acres) by 2010. The 2010 and subsequent targets have been setback by as much as 4 years as a result of implementing the Yellowstone fish passage project as outlined in a letter from the USFWS to the USACE dated October 23, 2009. To date, the USACE has created approximately 3,443 acres of SWH, which increased the total available on the Missouri River system to 9,201 acres (Jalili and Pridal 2010). The Missouri River 2011 flood may have affected these SWH areas and acres present and the USACE plans to conduct an assessment of SWH in 2012 when the flood waters recede.

Summary of SWH-related monitoring and investigations to date

In 2001, the Pallid Sturgeon Population Assessment Program (PSPAP) was initiated to document trends in pallid sturgeon and native fish communities. Monitoring efforts continue to show a lack of natural recruitment in the pallid sturgeon population with any population growth resulting almost entirely from stocking of age 1 fish (Welker and Drobish 2010).

The Missouri River Fish and Wildlife Mitigation Program Fish Community Monitoring and Habitat Assessment of Off-Channel Mitigation Sites was conducted from 2006-2008 with an objective to "determine biological performance and functionality of chutes and backwaters and to compare chutes and backwaters in an effort to identify designs most beneficial to native Missouri River fish species" (Sterner et al. 2009). This effort provided evidence that side-channel chutes provided habitat for young benthic riverine fishes while backwaters provided habitat for different species of fish such as sunfishes, shads, temperate basses, and sauger. It also provided evidence that natural chutes and older created chutes had more diverse fish communities when compared with younger created chutes. The study also provided evidence that chutes that were longer, wider, shallower, and more sinuous were more likely to have target species present. Evidence was also provided that "juvenile and small-bodied fish utilized

shallow water habitats (<1.0 m) over a broad range of water velocities (0.0-1.0 m/s), but large-bodied fishes tended to orient towards relatively deeper water (Sterner et al. 2009).

In 2006, the Habitat Assessment and Monitoring Program (HAMP) was initiated to evaluate the physical and biological responses to structure modifications/additions designed to increase SWH within the main channel (Hall and Sampson 2009). The HAMP uses a Before-After/Control-Impact design focused at the river bend level to monitor fish communities and depth/velocity distributions in both "treated" and "control" bends. A 2010 analysis of HAMP data collected to date did not detect any differences in fish catches between treated and control bends and pointed to a need to evaluate explicit hypotheses related to the role of SWH (Schapaugh et al. 2010) to determine why. This analysis also developed numerous recommendations for future SWH monitoring efforts including:

- Develop life-history models connected to habitat metrics for each species of interest
- Collect data linking specific strategies for increasing SWH with productivity at multiple spatial scales
- Repeat the 2007 physical habitat survey to begin estimating rates of change in SWH for different practices, and ensure the information is available to compare with fish sampling data
- Any redesign of the monitoring program must include new power analyses that take advantage of recent methods for analyzing count data and are directly connected to information needs for decision making
- Hierarchical sampling at more than one spatial and temporal scale (e.g. among neighboring bends, at bends, and within bends at creation sites) should be considered in future re-visitations of the sampling design
- Collect additional measures of productivity (linked to life history) that respond quickly and can be detected within each bend.

In 2008, a water quality monitoring program for the MRRP was initiated which is partially aimed at addressing the effects of SWH projects on water quality, especially those related to sediment reintroduction and potential nutrient and contaminants inputs during SWH creation efforts (USACE 2010).

In addition, two conferences were held to identify and prioritize research needs related to pallid sturgeon. The first was held in 2004 in Bloomington, MN (Quist et al. 2004) with the second held in 2007 in St. Louis, MO (Bergman et al. 2008). From each of these conferences, a need for increased research on early life stages was emphasized.

In 2004, the Comprehensive Sturgeon Research Project (CSRP) was initiated to address some of the fundamental research needs for understanding pallid sturgeon reproductive biology (DeLonay et al. 2010). Publications from this ongoing project address reproductive ecology, movements, physiology, habitat use and dynamics, spawning site selection, and population dynamics. These studies have found that pallid sturgeon mature, they are capable of finding each other prior to spawning, and they spawn. Hatchery released fish have also matured and spawned and appear to survive well. Studies have also found the types of areas where pallids are

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currently spawning do not appear to be rare. These findings continue to support the idea that a bottleneck is occurring somewhere between the act of spawning and recruitment to age 1. Numerous other investigations have been undertaken to address uncertainties related to pallid sturgeon including a 2007 study seeking to quantify trophic position of pallid and shovelnose sturgeon, (French 2010), a 2007 effort to address vulnerability of age-0 pallid sturgeon to predation (French 2010), a pair of 2008 pallid sturgeon iridiovirus studies (Beck et al. 2008) (Hendrick et al. 2009), a 2008 study addressing sediment management which related in part to the input of sediment due to SWH projects (Jacobson et al. 2009; NRC 2010), and a 2009 combined laboratory and field study of growth and survival of larval pallid sturgeon.

Uncertainties

There are numerous uncertainties associated with the construction of SWH and the degree to which the management actions may or may not meet the stated objectives. While many of these uncertainties may be addressed through monitoring (see Section 4), focused investigations (see Section 5) will also be necessary to address uncertainties that cannot be addressed through planned monitoring activities.

Time needed for habitat development

One significant source of uncertainty is the time needed for full development of habitat after a construction activity. As hard constraints to river morphology are altered through restoration activities, natural erosional and depositional processes act to create and maintain SWH. Although these habitats may be primarily erosional at the onset, the river channel and associated SWH should eventually reach a dynamic equilibrium governed by discharge and sediment supply. However, there can be a significant lag time (many years, even decades) between the management action of constructing SWH and the desired condition of the habitat (Jacobson et al 2001; Jacobson et al. 2004). The amount of time needed for development of different types of SWH projects due to hydrogeomorphic processes is somewhat uncertain and depends on flows, project type and design, and location. Understanding the rate and likelihood of habitat progression is critical in evaluating biological responses.

Habitat-benefit relationship

Over 100,000 acres of SWH was lost as a result of the BSNP and to date only a fraction of that has been restored (USACE 2003). The target acreage in the BiOP is 20% of the historic acreage. Benefits of SWH to fish species are likely to be cumulative in nature, non-linear, or governed by thresholds. Population-level benefits to the pallid sturgeon and the native fish community may not be measurable until a significant amount of habitat is restored. It is uncertain how much habitat may be needed in order to begin measuring these benefits through population responses.

Benefits to Pallid Sturgeon

It is hypothesized that SWH benefits pallid sturgeon by slowing larval drift/increasing retention of larval fish, by providing nursery areas for larval/young-of-year fishes, and by increasing production and/or retention of food sources in these areas of the river. Hypothesized links between SWH creation and the life history of pallid sturgeon are depicted in the CEM and associated hypotheses (Appendix A). Although creating SWH is necessary to restore a semblance of natural form and function to the river, the extent to which lack of SWH is limiting to individual species, most notably pallid sturgeon, is uncertain.

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Scale of SWH projects

Habitat benefits to species may depend on size, complexity, and connectivity of habitat patches. For Missouri River native fishes, including pallid sturgeon, it is uncertain whether fewer large SWH projects or many small SWH projects have different benefits for target species. Additionally, the potential benefits of clustering SWH in complexes are unknown.

Distribution relative to other habitat types

The current spatial distribution of SWH projects has resulted mainly from where land ownership has provided opportunities for construction and to provide a somewhat even distribution of projects. The distribution which would optimally benefit pallid sturgeon is uncertain. For example, it is unknown whether projects should be concentrated upstream in areas where SWH is most scarce to aid in slowing larval drift or if instead projects should be concentrated downstream where larval sturgeon would likely "settle" out of the drift on today's River. The potential importance of placing projects in specific locations, such as near the mouths of major tributaries, is also unknown. While distributing SWH evenly or proportional to historic distribution may make sense in relation to Mitigation Project objectives, this distribution may not be the most beneficial to pallid sturgeon (or some other native species) in today's River.

The amount of habitat that can be restored without impacting navigation

Although SWH experience demonstrates that navigation and SWH restoration can coexist, it is uncertain exactly how much habitat can be restored before too much water is diverted from the main channel and navigation or other authorized purposes on the system are impacted.

Amount of SWH that needs to be restored

SWH addresses recommendations from the 2003 Amended BiOp, which called for restoration of 12,035-19,565 acres of SWH to meet an overall goal of 20-30 acres per river mile (15,060-22,590 total acres). SWH construction also addresses the provisions of the BSNP Mitigation Program which calls for 7,000-20,000 acres of habitat of this type (USACE 2003). It remains uncertain how much of this habitat is needed in order to achieve the ecological objectives and whether there is a linear relation between habitat area and ecological functions. Currently, about 3,443 acres have been constructed with the potential of those projects to produce twice that amount in the future as habitat develops. There are approximately 9,400 acres of SWH currently present between Ponca, Nebraska and St. Louis.

Relative benefits of different types of SWH

Under natural, historically-documented conditions, SWH existed in many forms including sidechannel chutes, backwaters, and within-channel habitats. The relative amounts needed and benefits of each habitat type to fish communities are uncertain.

Water Quality

Missouri River basin land-use has been highly altered from its historical condition and water quality has been consequently diminished including increases in nutrients,

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bacteria, and some contaminants; decreases in sediment load and turbidity, and episodic sags in dissolved oxygen (Blevins and Fairchild 2001; Poulton et al 2003; Turner and Rabelais 2003). Bioaccumulation of PCBs, chlordane, and mercury in sturgeon has resulted in advisories to limit consumption of flesh and to never consume sturgeon eggs (MDHSS 2011). Nevertheless, two recent studies of contaminants in sediments and associated effects in benthic insect communities identified only a few hot spots of contamination along the Lower Missouri River (Echols et al. 2008; Poulton and Allert 2011). These data indicate the potential for water quality and contaminants to adversely influence biological outcomes of SWH projects, but the magnitude of effects are currently unknown.

Efficient construction of SWH typically involves removing sediment from floodplains to expand the channel or off-channel area. Although floodplain sediments generally have low potential for contamination (Schalk et al. 1997; CDM Federal Programs Corporation 2007), concerns have been raised that delivery of this sediment to the Missouri River could deliver contaminants and excess nutrients. Calculations show that contaminants and nutrients that would be delivered to the river are low compared to background fluxes and are unlikely to pollute the river or contribute to Gulf Hypoxia (NRC 2011; Jacobson et al 2009). As a result of these concerns, the USACE is conducting elutriate sampling prior to chute construction to better understand nutrient and contaminant contributions from habitat creation activities.

Interaction between flows and the availability and functionality of SWH

The benefits of restoring some natural form to the River (SWH construction) are not only dependent on changes to channel form but also the interaction with flows (Jacobson and Galat 2006). Biological outcomes may not be achieved even with desired changes to channel form if flows negatively affect the quantity, functionality, and timing of the SWH created. A more detailed understanding of this interaction in relation to pallid sturgeon, functionality of SWH projects, and authorized purposes may be needed.

Strategy Development

This AM Strategy was developed in accordance with numerous guiding documents relevant to the MRRP. The 2000 BiOp and its 2003 amendment call for establishing an AM process to evaluate species and habitat responses to management actions within the River and to continually provide knowledge for the decision-making process (USFWS 2000, 2003). In addition, the USACE recently released a Technical Memorandum describing implementation guidance for Section 2039 of the Water Resources Development Act (WRDA 2007) which calls for monitoring and AM of ecosystem restoration projects and provides some specific direction on what is to be addressed within AM plans. Finally, the National Research Council (NRC) calls for AM efforts in their 2002 report *The Missouri River Ecosystem: Exploring the Prospects for Recovery* (NRC 2002). These documents were used in the development of the draft Missouri River Recovery Program Adaptive Management Process Framework; a document which lays out the AM process that will be integrated into the MRRP and which guided the development of this AM Strategy.

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Strategy development was initiated by a multi-agency product delivery team (PDT) consisting of representatives of the USACE, U.S. Fish and Wildlife Service, U.S. Geological Survey, Missouri Department of Conservation, Environmental Protection Agency, Iowa Department of Natural Resources, and Nebraska Game and Parks Commission. This team, which will be referred to as the SWH PDT, met on several occasions to develop components of this document and to review drafts of the AM Strategy. A list of the PDT members can be found in Appendix D. Additional components of the strategy were developed by the Adaptive Management Work Group (AMWG) and Habitat Assessment and Monitoring Program (HAMP) manager and provided to the SWH PDT for comment. This document is a joint product of the US Army Corps of Engineers (USACE) and the US Fish and Wildlife Service (USFWS). Although other groups and agencies have contributed to its development and may be involved in the implementation process described, this document has not necessarily been endorsed by any of these interests.

Objectives

In evaluating SWH projects, one of the main challenges is defining expectations (i.e. what does success look like and how do we determine when it is achieved?). These expectations occur at several levels and each is important. First, it is necessary to understand whether management actions are creating the desired physical habitat characteristics (i.e. SWH). Much of the guidance for success criteria regarding physical habitat comes from the BiOp and associated clarified definition of SWH which describe target acreages, distributions, and general qualitative characteristics of SWH. Further detail regarding desired physical attributes can be obtained from the best examples of SWH currently present on the River (i.e. those habitats which best produce the desired fish responses). Since even the best current examples of SWH are altered it will also be important to compare to historic conditions where possible. Historically-documented channel conditions and habitat distribution can provide a reference for the direction of restoration strategies, a useful understanding of the processes that likely operated in the pre-engineered river, and an understanding of the degree of habitat degradation of the highest quality habitats currently available but with the understanding that the historical condition may not be achievable. A meaningful restoration goal is to restore some or all of these processes and habitat types, albeit often over a smaller scale. This is consistent with the articulated goal of restoring about 20% of the historical SWH (USFWS 2003).

Determination of success in restoration of SWH is also dependent on defining a timeframe for evaluation. For physical aspects of habitat restoration there is a need to understand timeframes required for created habitats to develop through natural processes (e.g. erosion and deposition), to a state of dynamic equilibrium. For example, excavation of a chute pilot channel may only require a few months but development of that pilot channel into a chute which resembles a more natural chute may take decades. The degree to which the desired progression occurs and the time required to achieve such a dynamic equilibrium is unknown and has been identified as a critical uncertainty. Furthermore, in evaluating biological responses, it is important to understand the state of physical habitat development.

Next, it is necessary to understand whether the anticipated biological responses are occurring at the project scale. Because system-wide biological responses may not be observable until many SWH projects have been added to the system, project-level responses will be important in evaluating progress in the short term. Guidance regarding these project-scale metrics come from

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the inter-agency Aquatic Habitat Working Group (AHWG), the BiOp and clarified definition of SWH, and an abundance of research on the importance and role of SWH in lotic systems. Project-scale metrics are also necessary to evaluate hypothesized linkages between SWH actions and fish identified in the CEM (Appendix A) as well as evaluate performance of individual project designs. Although project-level responses are expected to occur as habitat develops, the relationship between habitat development and biological response may not be linear.
Finally, if the desired physical and biological responses are occurring at the project scale, the system-wide response (i.e. increasing abundance of pallid sturgeon and other native fishes) must be evaluated to determine if SWH creation is having the desired effect or if other means need to be considered. System-scale changes in populations of pallid sturgeon and the native fish community may have a longer lag time in the response as more habitat is added to the system. For a very rare, long-lived, late-maturing fish like the pallid sturgeon, some responses may take even longer than those of other native fishes. Moreover, it is possible that populations of pallid sturgeon or other native fishes are not limited by SWH quantity or quality, or the relationship is non-linear or governed by thresholds. If the former of these is true then fish populations will not respond to SWH creation efforts. If the latter is true, population response may not be proportional to SWH availability.

The following objectives were developed to formalize the desired outcomes of the SWH sub-program with respect to both the BiOp and BSNP Mitigation Project goals of benefitting pallid sturgeon and other native fishes. Where applicable, specific references are made to the connections between these objectives and conceptual life history models for pallid sturgeon. The primary management action of creating SWH is meant to accomplish the fundamental objective of increasing the abundance of pallid sturgeon and other target fishes (Obj. 1) by increasing the overall abundance of SWH throughout the target segments (Obj. 2). SWH creation aims to restore some of the natural form and function of the river by increasing the physical habitat complexity as measured in changes to key physical parameters (Obj. 3). As a result of physical changes to channel form, biological responses are expected to occur at the project scale (Obj. 4) and as more SWH is added to the system, biological responses are expected to occur at larger scales including increased abundance of pallid sturgeon and other target species (Obj. 1). Progress toward all four objectives will be assessed.

Fundamental objectives

System-wide responses of pallid sturgeon and other target fishes

With regard to the BiOp, increasing abundance of wild pallid sturgeon is the fundamental objective of SWH creation. Although other objectives are important for the Fish and Wildlife Mitigation Project or as “means” objectives for evaluating hypothesized linkages between SWH actions and pallid sturgeon, it is the response in the pallid sturgeon population that will ultimately determine success of SWH creation efforts in meeting BiOp compliance.
This objective addresses fundamental objectives associated with the BiOp and BSNP Mitigation Project of benefitting pallid sturgeon and other native fishes and will mark the ultimate measures of program success. When targets for these metrics do not exist due to a lack of historic information, targets are framed in terms of population trends in demographics and catch rates that will be monitored over time.

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Increasing abundance of native cyprinids, which include native chub species, is directly connected to pallid sturgeon life history since they are believed to be key prey fishes for juvenile and adult pallids (Gerrity et al. 2006). Providing benefits to all native fishes is a fundamental objective of the BSNP Mitigation Project.

Objective 1.1: Increase survival and recruitment of free embryos to exogenously-feeding larval pallid sturgeon
Performance Metrics: Catch rates of larval and YOY pallid sturgeon over time

Objective 1.2: Increase survival and recruitment of YOY pallid sturgeon to age 1
Performance Metrics: Catch rates of YOY and age 1 pallid sturgeon over time, pallid sturgeon population size structure changes over time, changes in growth/condition over time

Objective 1.3: Increase survival and recruitment of larval, YOY, and small-bodied big river, native fishes
Performance Metrics: Catch rates of young and small-bodied native fishes over time, changes in size structures of native fish populations over time, changes in growth/condition over time

Objective 1.4: Restore a self-sustaining population of pallid sturgeon
Performance Metrics: Pallid sturgeon population size structure changes over time, pallid sturgeon abundance over time

Means objectives

Shallow water habitat creation and distribution
These means objectives address habitat goals stated in the BiOp and the BSNP Mitigation Project. Estimates of SWH acreage in 2010 indicate that, as of 2009, approximately 3,443 acres of SWH had been created (Jalili and Pridal 2010). Using acres provided in Table 1 of Jalili and Pridal (2010) from the Acres/Mile (GIS) column, it was derived that in segments 11-15, there is currently approximately 9,500 acres of SWH in these 753 river miles, or approximately 12.6 acres/river mile. While this is currently measured by a combination of surface area with representative bend samples of physical characteristics less than 5 feet deep and less than 2 feet/second), the methodology outlined in the SWH AM Strategy for evaluating physical habitat changes and project-scale biological response (Objectives 3 and 4) will provide the basis for future accounting of qualitative aspects consistent with the clarified definition of SWH.

Objective 2.1: Increase abundance of shallow water habitat
Performance Metric: Acres/mile of SWH
Measurement: Bathymetry / aerial photography / structure modification model
Initial Target: 19,565 acres of SWH to be achieved by December 31, 2024

River segments for restoration of SWH derived from the BiOp are: segment 11 (Ponca, Nebraska to Sioux City), segment 12 (Sioux City to Platte River), segment 13 (Platte River to Kansas River), segment 14 (Kansas River to Osage River), segment 15 (Osage River to mouth). Current distributions of SWH are estimated to vary from 4.8 acres/river mile to 20.8 acres/river mile and tend to increase from upstream to downstream (Jalili and Pridal 2010). A literal interpretation of the BiOp could indicate that all of the target segments should have 20-30 acres per river mile of

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SWH and that focus should be placed on increasing the amount of SWH in areas that currently have less. However, as SWH was likely lost proportionally along the target segments and it is assumed that historic distributions of SWH would have scaled with the size of the river (which increases from upstream to downstream), the initial selected target is to add SWH equally to all target segments in proportion to the length of the segment. This is also consistent with the BSNP Mitigation strategy which seeks to restore habitat in each State (Iowa, Nebraska, Kansas and Missouri) in proportion to the amount of Missouri River shoreline that State has. However, it should be noted that investigations are needed to resolve uncertainties associated with the biological implications of SWH distribution. One investigation already undertaken has indicated that SWH is most critical for larval and juvenile sturgeon in Segments 14 and 15 (Delonay et al. 2009). This was based on an analysis of potential drift distances for pallid sturgeon larva. However, this study also describes the existing conditions in Segments 11, 12 and 13and states that, in these segments, the "…lack of marginal habitat probably limits retention of drifting larvae (Delonay et al. 2009). As such, there may be some benefit to placement of SWH in upstream segments to reduce drift distances of larval pallid sturgeon as well as in downstream segments to provide larval and juvenile rearing habitat. As such, this objective has the potential to affect both the "free embryo to larval stage" of pallid sturgeon due to effects on drift distance, as well as the "larval stage" by providing productive habitat conditions in areas where sturgeon are likely to fall out of drift and start feeding (Wildhaber et al. 2011). Once these uncertainties are resolved, the target for this objective will be updated to reflect the biological needs associated with habitat distribution.

Objective 2.2: Distribute SWH amongst target segments
Potential Performance Metrics: Acres of SWH per target river segment
Measurement: Bathymetry, aerial photography, structure modification model
Initial Targets: Add constructed habitat in equal proportions to all target river segments

Table 1: Current Distribution of SWH

Segment	River Miles in Segment	Acres of SWH to be Restored
11: Pona to Sioux City	18	468
12: Sioux City to Platte River	139.5	3,625
13: Platte River to Kansas River	228	5,924
14: Kansas River to Osage River	237.1	6,161
15: Osage River to St. Louis	130.4	3,388
Total	753	19,565

Physical characteristics of created shallow water habitat

These objectives address physical habitat changes and uncertainties related to whether SWH projects result in the desired physical changes to the Missouri River. Analysis of progress will

compare physical characteristics of created sites, best-achievable sites, historic conditions where available, and the mainstem of the Missouri River. While there may be some initial change following construction, achievement of this objective may require a longer period of time as created habitats develop through erosion and deposition. Also, the time needed to reach a dynamic equilibrium in habitat development may be heavily dependent on the frequency and duration of high flow events. A key component will be to track progress over time to determine whether habitat changes are occurring in the desired direction. Assessing the physical changes which are occurring as a result of management actions will be essential in understanding biological responses. Although there are many physical metrics which could provide insight into the changes arising from management actions, the focus will be on those metrics which are measurable and most closely linked to the ecological functions of SWH. Presently, narrative and qualitative ideas exist for complexity metrics, but they have not been formalized as quantitative metrics or targets. Development of quantifiable metrics and targets for complexity is envisioned as a high-priority supporting investigation that can be accomplished through mining and analysis of existing and historic river morphology data or through the initiation of physical monitoring of both created and selected reference sites. Initial targets will be developed from collaboratively determined habitats in "best achievable" reference reaches identified along the river. Identification and measurement of "best achievable" reference reaches is also considered a high priority for supporting investigation.

Objective 3.1: Emulate depth and velocity distributions of best-achievable habitats
Performance Metrics: Depth and velocity distributions
Measurement: Bathymetric and acoustic Doppler surveys
Target: Use best-available habitats and historic data to develop targets

Depth and velocity have been the primary metrics used to define SWH. Although SWH can include a diversity of depths and velocities (according to the clarified definition provided by the USFWS), these habitats are intended to provide relatively slow, shallow water compared to the mainstem. Very slow water velocities (i.e. a few cm/s) are critical for larval fishes especially and typically increase with fish size (Schiemer et al. 2001). Because of the ease of data collection and interpretation, depths may be used as the primary metric with evaluation of velocities at a subset of locations. Channel morphology is likely an important factor for all life stages of pallid sturgeon (Wildhaber et al. 2007). Additionally, depths and velocities are partially controlling factors for two of the other metrics of physical habitat complexity. Substrate size deposited in SWH is due to a combination of material present and water velocities. Retention of large woody debris (LWD) is due to depths, velocities and channel features.

Objective 3.2: Emulate substrate size composition found in best-achievable habitats
Performance Metrics: Substrate size distributions
Target: Use best-available habitats to develop targets

Substrate size is an important determinant of habitat use by many fishes and is a key determinant of benthic invertebrate abundance. Opportunities exist to affect substrate composition through changes to chute inlet structures, characteristics of notches, and modifications that affect velocity distributions within SWH. This would be measured at the project scale as the management

actions proposed are not likely to affect the overall availability of different sediment sizes within the Missouri River below Sioux City, IA.

Objective 3.3: Emulate the entrainment/retention of large woody debris found in best-achievable habitats
Performance Metrics: Abundance of large woody debris
Measurement: Count of woody debris pieces greater than 50 cm diameter, occurrence / 100m^2
Target: Use comparison to best-achievable habitats to develop target and/or compare to historic woody debris abundance where possible

Woody debris was historically much more abundant in the Missouri River and provided important habitat for macroinvertebrates as well as native fishes. Woody debris also provides structural complexity which can provide refugia for young fish and invertebrates. Today's river is very efficient at moving woody debris through the system. The steep-sided, fast-flowing river provides few places to hold woody debris. Physical characteristics of created SWH should promote entrainment/retention of large woody debris. The connection of LWD to pallid sturgeon life history is largely related to its ability to provide habitat complexity and flow refugia to young fishes, including pallid sturgeon. Also, LWD can increase local abundance of benthic macroinvertebrates which are the primary food sources for juvenile pallid sturgeon (Grohs et al. 2009). In addition, LWD may provide habitat for small-bodied fish which are an important food source for immature to mature adult sturgeon.

Objective 3.4: Increase lateral connection of created habitat between the Median August flow level and the Ordinary High Water Mark
Performance Metric: Elevation profiles, wetted area/river stage relationships, lateral movement of bank
Measurement: Use of elevation survey data, bathymetry during high water, development of flow exceedence-discharge relationships, aerial photography to measure extent of bank migration rates
Target: Use comparison to best-achievable habitats and/or historic data to develop targets

Historically, the amount of SWH increased as river stages increased but today, due to channelization and the incised nature of the river, the amount of SWH decreases as river stage increases until the high bank is overtopped (Jacobson and Galat 2006). This is due to the loss of gradually-changing bank elevations replaced by steep, high banks. Restoring the direct relationship between river stage and SWH area at project sites is important in providing functionality characteristic of historic SWH at a range of flows thereby decreasing on specific flow targets (Jacobson and Galat 2006). Desired elevations (i.e. reduced bank slopes) evolve over time through erosion and deposition processes and will need to be evaluated over time and compared to initial conditions as well as the best examples of best-achievable habitats.

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Project-scale biophysical and biological responses

These objectives further address functional aspects of SWH. These metrics focus on the project-scale biological responses which are necessary to provide the linkages between SWH and fish. These metrics are necessary not only to assess the quality of created habitat in the short term but to evaluate the hypothesized linkages between habitat creation and fish population responses which may lag.

Presently, metrics for these objectives have not been formalized as quantitative metrics or targets. Selection of project-scale metrics is based on the hypothesized linkages depicted in the SWH Conceptual Model (Appendix A). Development of quantifiable metrics and targets is envisioned as a supporting investigation. Initial targets will be developed from needs of larval/YOY pallid sturgeon and other native fishes as well as conditions present in "best achievable" reference reaches identified along the river.

Objective 4.1: Increase local abundance and species diversity of native larval, young-of-year, native cyprinids (sturgeon chub, sicklefin chub, shoal chub, blue sucker, sand shiner, Hybognathus spp.) and other target native fishes (sauger, catfishes, paddlefish, shovelnose sturgeon)
Performance Metrics: Abundance of target fishes and size classes, fish community diversity
Measurement: CPUE and length frequencies of target fishes
Target: based on the best examples of SWH and comparisons to other available habitats

SWH is intended to provide nursery areas for larval and YOY pallid sturgeon and other native fish in part by providing conditions which retain these small fishes and provide relatively benign, predator-free habitats. These types of habitats have been found to be critical for the recruitment and year class strength of larval and YOY fish (Schiemer et al. 2001). As such, it is important to determine if those fish are able to access the habitat and if the created habitat is more suitable than habitats already present. Information on the use of these habitats relative to other habitats by YOY/small-bodied fishes will help evaluate whether quality nursery habitats are being created. Relative abundance of larval fishes in these habitats compared to other habitats will indicate whether created habitats have increased ability to retain larval fish.

Objective 4.2: Provide appropriate feeding/nursery areas for larval/YOY, and small-bodied fishes by creating SWHs where 1) water warms more quickly and reaches higher temperatures than currently found in main channel, 2) organic matter retention rates are higher than in the main channel, 3) terrestrial vegetation establishes in the transition zone between water line at median August flow and the ordinary high water mark, and 4) benthic invertebrate abundance is higher than in the main channel
Performance Metrics: 1) water temperature, 2) total organic carbon in sediment, 3) vegetation abundance between median August flow and Ordinary High Water mark, 4) benthic macroinvertebrate abundance and composition
Measurement: 1) temperature readings, 2) sediment samples, 3) vegetation survey, 4) plankton tows and benthic grab samples. Water quality data will also be collected to allow for interpretation of results (temperature, turbidity, DO, total suspended solids).

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Target: Compare to other habitats and to needs of pallid sturgeon and other target fishes

Habitats which retain larval/YOY fishes must also provide the right food resources at the right time. A lack of appropriate food, particularly at the larval stage, is often a bottleneck for successful recruitment in fish populations. The success of SWH creation efforts will depend on an ability to provide these conditions. For example, organic matter retention and production/retention of phytoplankton, zooplankton, and benthic invertebrates in these habitats is necessary and must coincide with conditions which also retain drifting larval fishes.

Management Actions

The following section describes the suite of management actions that may be taken to implement the SWH sub-program. Potential adjustments include modifications to previously constructed projects which may be undertaken so projects better meet the stated objectives. Potential future management actions include those things that are not likely to be implemented in the short term due to either high levels of uncertainty, policy challenges, or a lack of authority to undertake the action.

Primary management actions

There are currently three categories of primary management actions undertaken to restore SWH: structure modifications, construction of new structures, and creation of off-channel habitat. These management actions are described below and examples of each are provided with additional detail.

Structure Modifications

The following management actions describe modifications to existing Missouri River control structures to restore processes which create shallow water habitat. The cost to modify existing structures is typically between $25,000 and $70,000 per modification and is believed to produce between one and six acres of SWH; a cost of between $4,000 and $70,000 per acre of SWH. Structure modifications are typically less expensive than habitat creation actions such as backwaters and chutes, but there is uncertainty regarding the amount of SWH that will ultimately be formed by structure modifications as well as the amount of time or number of high flow events required for formation/development of the habitat. There is also uncertainty regarding the biological benefits of these actions. Benefits of structure modifications include short construction timeframes, lower construction costs, and they often do not require real estate interests to accomplish. Following is a description of the different types of structure modifications that may be undertaken to increase SWH.

Bank notches

A Bank Notch (also referred to as a Type-B notch) consists of excavating a 100’ to 150’ long, 75’ wide section of the high bank along with the under-laying 75’ wide section of buried L-Head or straight out dike. The invert of a bank notch is excavated to 5’ below CRP using land-based equipment. Bank notches have numerous immediate and long term effects. The immediate effects include the creation of a secondary channel adjacent to the high bank as the water enters the upstream most notch and flows along the bank through the downstream bank notches. Deposition will occur riverward of the secondary channel resulting in sandbar formation and shallowing of the area between the dikes. The resulting habitat has greater depth and velocity

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variation than the pre-notch condition. The long-term effects are erosion of the high bank and widening of the top-width of the river. Depending on the size and location of a notch, the flow can be used to erode the bank and increase diversity upstream and downstream of a notch or, if bank line erosion cannot be tolerated, the flow can be used to only increase diversity. In general, the larger the notch and the closer the notch is located to the bank, the more the adjacent bank will erode and the more diversity will increase in the general area. Based on analysis of past and current bank notching efforts, it is estimated that one bank notch will create between 4 and 6 acres of diverse shallow water habitat. As of 2009, 219 bank notches have been completed which have provided between 507 and 822 acres of SWH.

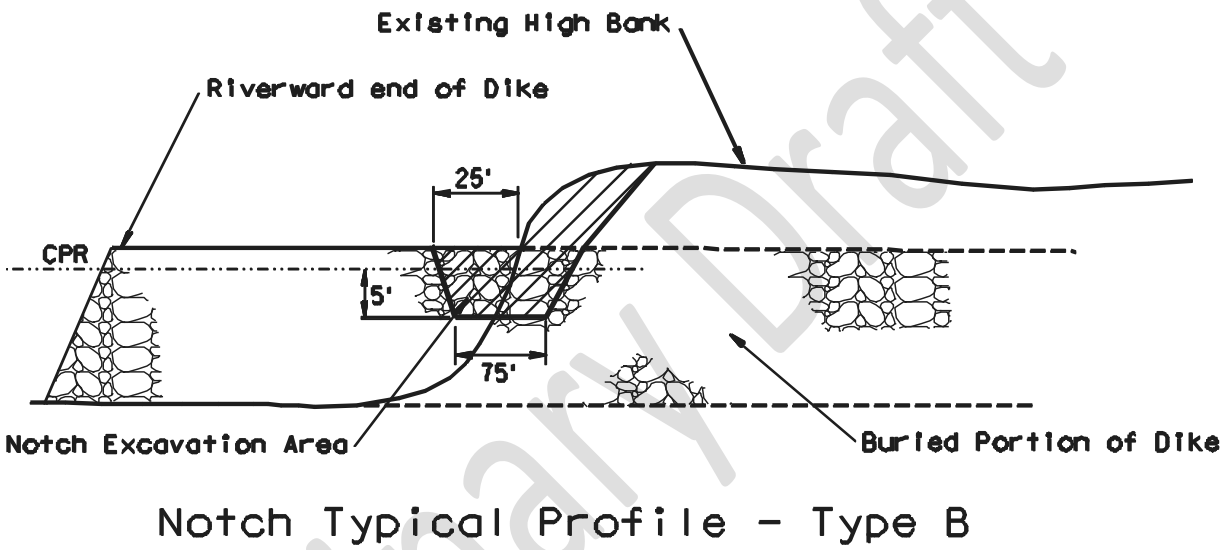
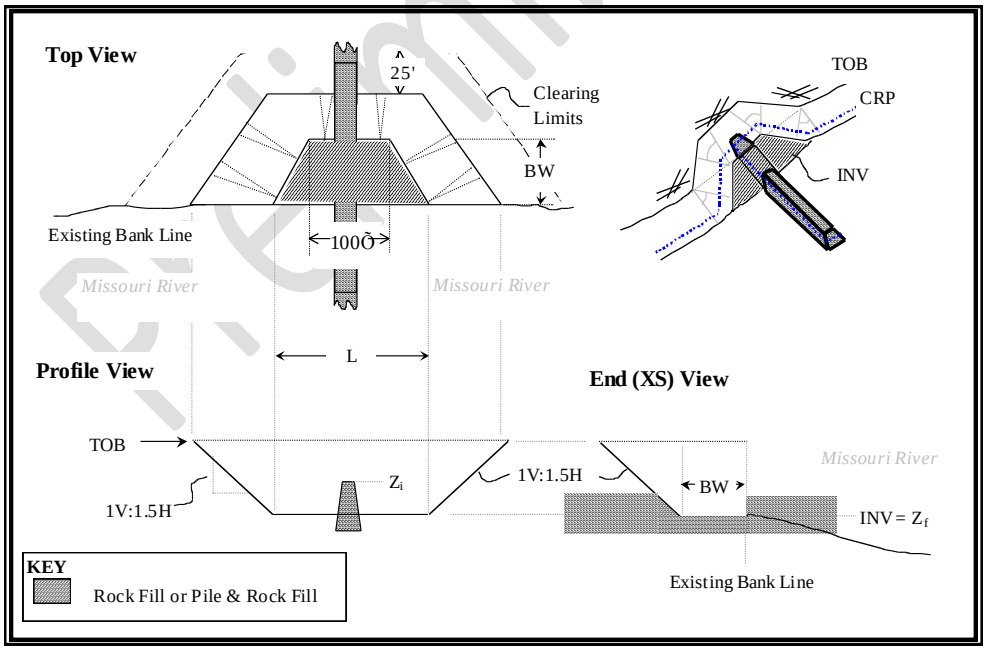


Figure B: Profile view of a typical dike notch



*CRP = Construction Reference Plane = Elevation Representing Flow Exceeded 75% of the time

Figure C: Top view of a typical bank notch.

Dike Notches

A Dike Notch consists of excavating a 50' to 100' wide section of a dike to an elevation either 4' or 5' below CRP. Dike Notches are placed entirely riverward of the high bank, but not further than the halfway point between the high-bank and riverward end of a dike. Dike notches are most often constructed using water-based equipment, but may also be constructed using land-based equipment.

Physical changes expected from dike notch construction include the diversion of flow from the main channel through the notch, and then back to the main channel. Flow diversion creates a side channel formed by sand bars on each side, often to the elevation of the un-altered portion of the dike. A scour pool forms downstream of a notch due to increased turbulence from flow plunging over the notch. Localized bank erosion is expected downstream of dike notches constructed in close proximity to the bank. Based on Corps of Engineers analysis of dike notching, it is estimated that a 50' dike notch will produce one acre of shallow water habitat and a 100' notch will produce two acres of shallow water habitat (USACE 2004). As of 2009, approximately 950 dikes have been notched resulting in an estimate of between 700 and 3,800 acres of SWH.

Figure D: Dike Notches, Lower Little Sioux Bend

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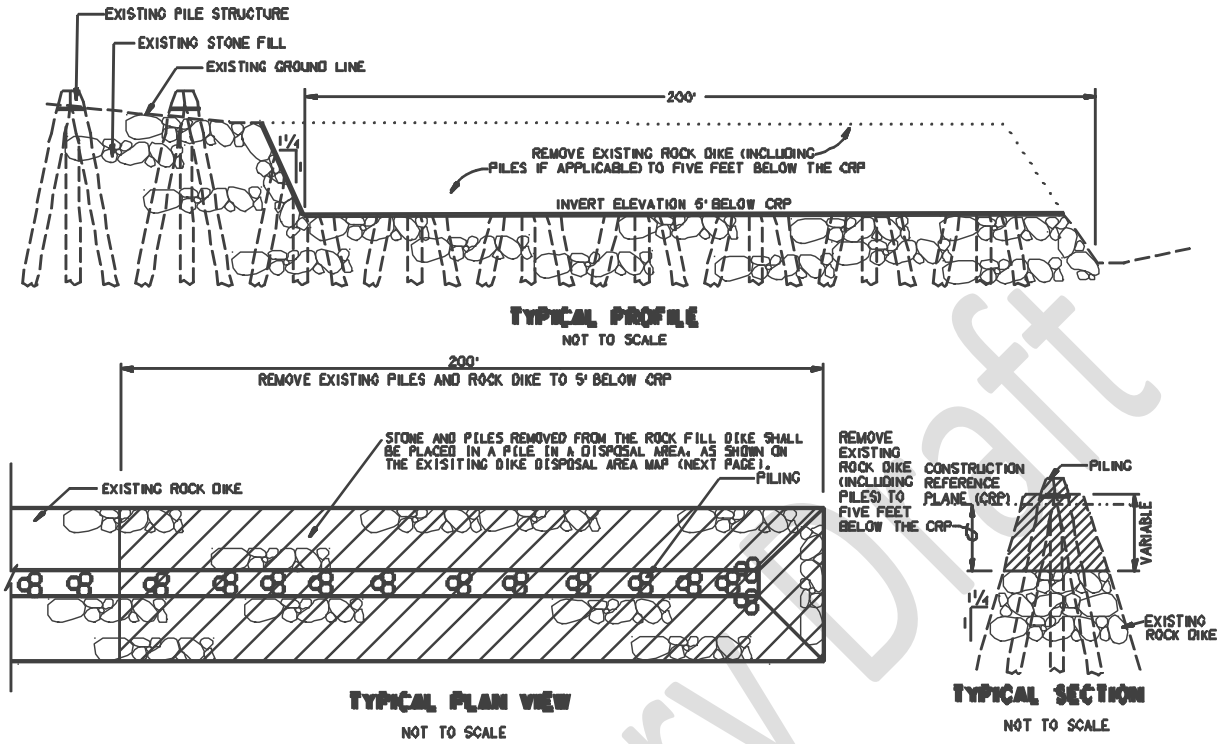

Figure E: Profile view of a typical dike notch.

Revetment notches and lowering

Revetments were constructed as part of the Bank Stabilization and Navigation Project (BSNP) to induce channelization of the River and prevent bank erosion. A Revetment Notch consists of excavating a 50' to 100' wide section of a stone-fill revetment to an elevation 5' below CRP using water- or land-based equipment. Without notches in the revetment, these aquatic areas are poorly connected to the main channel at normal summer flows, and therefore have little to no flow, no velocity diversity, and no fish access. Revetment notches are placed at locations where a slack water pool is separated from the main channel by a stone fill revetment, or along a L-head revetment. In most cases notches are cut at the upstream and downstream end of the pool to maximize the effects of the notches.

Physical changes expected from a revetment notch include a scour pool on the landward side of a notch. Scour pools are created due to increased turbulence from flow being diverted from the main channel and plunging over the revetment. Accordingly, as compared to the previous, disconnected condition, greater diversity in velocity and depth is expected on the landward side of a revetment after notch construction. The size of a revetment notch controls the amount of water flowing into the adjacent pool, causing larger notches to have greater influence to the aquatic habitat environment. It is estimated that a 50' revetment notch will produce one acre of shallow water habitat and a 100' revetment notch will produce two acres of shallow water habitat (USACE 2004).

Revetment lowering consists of excavating an entire section of revetment 50' to 100' feet into the bank in order to allow the river to widen its top-width and form SWH. As of 2009, there

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were approximately 194 revetment notches and resulting in an estimate of between 160 and 570 acres of SWH and 2.1 miles of revetment was lowered resulting in an estimate of between 17 and 51 acres of SWH.

Figure F: Aerial view of a revetment lowering.

Figure G: Revetment lowering at low water, Lower Decatur Bend.

New structures

In addition to modifying existing structures, new structures could be placed in the River to encourage formation of SWH. Following is a list of potential new structures that could be placed to create SWH.

Chevron

A chevron is a "U" or "V" shaped rock structure that points upstream and is intended to induce deposition of substrate to form SWH as well as widening of the adjacent bank. Chevrons can be either closed or opened and may be modified to include wings or rootless dike-like structures. Chevrons may be grouped and placed in different configurations in order to use local conditions to achieve the desired objectives. As of 2009, 11 chevron's had been constructed in the target

segments which formed between 3 and 7 acres of SWH. Chevrons are anticipated to cost between $5,000 and $50,000 per structure and are anticipated to produce approximately 0.5 acres of SWH per structure.

Figure H: Aerial view of chevrons.

Rootless Dikes and Reverse Sills

A rootless dike is a stone structure perpendicular to the flow of the river that is completely detached from the bank, typically placed between two existing dikes. These structures increase the amount of SWH by causing river widening on the landward side of the dike and deposition of sand downstream of the dike. Reverse sills are similar structures to rootless dikes except that they are placed atop an existing dike and so are attached to the bank via a lower elevation dike. Rootless dikes and reverse sills are anticipated to provide approximately 1 acre of SWH each. As of 2009, 48 rootless dikes and reverse sills had been constructed, with an additional 19 reverse sills added to modified dike notches. These structures are estimated to have formed between 49 and 77 acres of SWH. Rootless dikes and reverse sills are anticipated to cost between $20,000 and $80,000 dollars per structure and are anticipated to produce approximately 1 acre of habitat.

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Figure I: Aerial view of a rootless dike.

Figure J: Reverse sills at Sandy Point Bend

Major dike modifications

Major dike modifications consist of lowering a large portion (approximately 200 feet) of the riverward end of a series of dikes and construction of chevron structures between each pair of lowered dikes. As of 2009, 207 major dike modification structures had been constructed which are estimated to have formed between 145 and 275 acres of SWH. Major dike modifications are anticipated to produce between 8 and 15 acres of SWH per mile.

Off-Channel Habitat

The primary methods used to restore off-channel habitat include creation of chutes and backwaters, widening the main channel, and altering existing levees. Habitat is constructed using mechanical equipment, hydraulic dredges, or a combination of both to excavate material from the floodplain. The major difference between backwaters and chutes is that chutes are connected to the river on both ends, contain flowing water, and are intended to develop over time through dynamic processes where backwaters are only connected at the downstream end, contain slack-water, and are constructed to the ultimate desired condition. For all habitat types,

additional transient benefits to water quality and sediment availability may be achieved through deposition of excavated material in the channel and through restoring natural erosion processes. The Missouri River currently has a reduced sediment load from historic levels and increased sediment is believed to benefit native fish species.

Chutes

A chute is a side-channel of the river which diverts flow from the main channel through the chute, and back into the main channel, thus creating an island. Chutes are typically constructed as a pilot channel which consists of a trapezoidal-shaped dredge cut 50' to 75' wide at the invert, excavated from the floodplain a depth of between two to five feet. While chutes could be constructed wider, this would be more expensive and result in fewer projects. Chutes have typically been constructed with minimal meandering. Increased initial meandering and chute length has benefits of increasing initial habitat area would cost more and could result in slower development.

Construction can be accomplished through the use of hydraulic dredges or use of excavators to remove material. Physical changes expected at chutes include bed and bank erosion of the chute, accelerated after construction, then following natural meander migration as the chute matures. Chutes are intended to have an ultimate width of between 125 and 300+ feet and a diversity of depths and water velocities. Chutes are the only SWH management actions that have the potential to produce some of the extensive lateral migration (alluvial cut and fill dynamics) that characterized the pre-engineered Missouri River. Other physical changes include sediment deposition downstream of the chute, eroding banks in the chute, and introduction of large woody debris into the river. If the entirety of a chute that was 1000' x 125'met the physical characteristics of SWH, it would provide three acres of SWH (USACE 2004). The biological expectations would vary with time as the chute develops. Reduced velocities in the chutes should contribute to deposition of fines and organics that contribute to establishment of vegetation as well as invertebrate production (secondary productivity). Vegetation contributes to increased deposition of fines through lateral diffusion of fines and organics into the vegetation. Vegetation provides escape cover for small and juvenile fish. Fish species that are typically found in chutes include blue sucker, shovelnose sturgeon, and chub species (benthic riverine species).

In naturally-functioning chutes and sidechannels, the entrances receive deposition first and this process proceeds in a downstream fashion. The "plugged" entrance contributes to reduced velocities and deposition within the sidechannel chute. As this process proceeds the sidechannel chutes changes depth, morphology, and velocity. It's likely that the summation of the variety of ecological stages within an area contributes to the areas overall value (i.e. habitat diversity). While this dynamic nature may contribute to many of the Objectives of the SWH AM Strategy, the energy within chutes also has the potential to cause excessive depths within chutes and higher velocities than desired which could require post-construction modifications such as inlet and grade control structures to achieve the desired benefits. As of 2009, there were 38 sites in the target segments where either single chutes or complexes of chutes were constructed totaling approximately 900 acres of SWH. The anticipated cost for chute construction is between $50,000 and $120,000 per acre for construction.

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Figure K: Side-channel chute at Kansas Bend.

Backwaters

A backwater is a floodplain feature which is connected to the river on the downstream end but disconnected at the upstream end under normal flow conditions. Because of this, backwaters have still water. Backwaters are constructed in a similar manner to chutes, however, they are not expected to have similar cut-and-fill dynamics. As such, backwaters are constructed to the desired ultimate depth, width, and slope configurations. Backwaters typically have higher water temperatures than chutes and can have high primary productivity; potentially high enough that algal bloom die-offs could reduce dissolved oxygen levels enough to impact aquatic organisms. Backwaters may be highly productive foraging areas. Fish communities in backwaters differ from those in chutes. Backwaters may contain higher numbers of sunfishes (centrarchids); shads (clupeids); temperate basses, walleye and sauger (perciformes). Slow, deep backwater habitats are also selected foraging habitat for invasive Asian carps; therefore these habitats will need to be monitored to assure that they do not enhance these populations. Backwater entrances have the potential to fill in over time due to sedimentation and may require periodic dredging. The backwater itself will tend to fill in over time so designs which reduce this rate will be preferred. As of 2009, 15 backwaters have been constructed in the target segment totaling approximately 413 acres of SWH. The anticipated cost for backwater construction is between $50,000 and $120,000 per acre for construction.

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Figure L: Backwater at Ponca State Park, Nebraska.

Channel Widening

Channel widening projects involve using mechanical equipment to lower the adjacent floodplain and bank of the Missouri River and create an adjacent "bench" of SWH. While some structure modification projects are intended to cause channel widening through erosion, this process can take many years and numerous structure modifications to complete. Channel widening projects seek to accomplish this in a shorter timeframe. Only one project has been planned using this methodology so far. These projects are expected to achieve the physical habitat complexity and project-scale biological benefits much sooner following construction, however they are also expected to be more expensive. The anticipated cost for channel widening is between $120,000 and $165,000 per acre.

Levee Alterations

Existing levees in the floodplain can be altered through notching or by setting back levees farther away from the channel to provide additional SWH under high-water conditions. This allows access of high-waters to additional floodplain areas and are likely to be most appropriate in areas where existing levees are close to the existing channel (> 0.5 mile). It should be noted, however, that these actions would not meet the current quantitative definition of SWH. The anticipated cost for notching levees is COST and the anticipated cost for levee setbacks is COST per UNIT.

Potential Adjustments

The following sections discuss potential adjustments that may be taken to alter previously created SWH sites to ensure that they better achieve the stated objectives.

Modifications to chute inlet

In cases where a chute is accepting either too much or not enough water from the main channel, an inlet structure may be either added or modified. Modification of a chute inlet typically costs between $300,000 and $600,000 and is expected to alter the maturation of a chute to reach the desired physical conditions described under Objective 3. In cases where too little water is coming into the chute, modifying the inlet structure would prevent the chute inlet from closing due to sedimentation, preserving the desired habitat type. Increasing flow through the chute may also be necessary if the chute is not developing as desired. In cases where too much water is

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entering the chute (possibly creating problems with maintaining the navigation channel), the size of the chute entrance may be modified to reduce the amount of water entering the chute. Because high flows through the chute are critical for initial chute development but reducing flow at some point may also have habitat benefits, planning control structures with a staged approach may have benefits. Chute inlet design may also impact fish access and/or bedload movement and modifications may be necessary when a problem is detected. These inlet structures can be modified in a variety of different ways to address physical conditions (flow and sediment load) at the inlet as well as biological factors such as fish access. The width, depth and shape of the inlet structure may need to be altered to achieve the right balance of flow and sediment load. Potential options for inlet structures include trapezoidal designs, v-shaped designs, and bottomless structures in which the width of the inlet is controlled but the depth is allowed to be altered by erosion and deposition processes.

Figure M: Inlet structure, Plattsmouth Chute

Modifications to Backwater connection

Backwaters are designed in a manner so that they maintain their connection to the river through a channel. In some cases, these channels may fill in faster than anticipated or be unable to maintain this connection. In these instances, these connections may be modified to include structures such as kicker dikes that divert flow and sediment to prevent deposition and maintain river connection. The anticipated cost for these modifications is approximately COST per UNIT.

Grade Control Structure

Grade control structures are used to limit downcutting within chutes and maintain the desired amount of flow in the chute. They may be placed as part of the original chute design or could be added later due to changing chute conditions. Grade control structures may degrade overtime and need replacement or repair. Grade control design may also impact fish movement or access. A typical grade control structure costs between $300,000 and $600,000.

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Figure N: Grade Control Structure Repair

River tie-back channel

In addition to providing increased acreage of shallow water habitat, the inclusion of river tie-back channels as project features are intended to provide increased habitat quality by providing a high diversity of depths and velocities in the complex, particularly at the intersection of the chutes and the tie-back channels. It is believed that these "edge" habitats are frequently used by sturgeon and other native fish species. These features could be added to introduce additional flow and depth diversity into existing or new chutes. Tie-back channels also provide additional avenues for fish access. The typical cost for a river tie-back channel is $_ per acre.

Figure O: River tie-back channel during low water

Modifications to initial chute design (pre-construction)

Side-channel chutes are typically constructed with a consistent channel width along the entirety of the chute. However, this design may not facilitate development of meanders and variable widths as well as alternative design options. One alternative design option is to vary the widths of the constructed chute. For example, instead of digging a channel of uniform width at 70 feet, some sections could be dug at 90 feet and some at 50 feet in a way that would not alter the volume of sediment moved. The benefit would be nearly immediate bathymetric diversity. If the wider portions were created at the bend apexes, then a more shallowly-sloped point bar could form. The result would be greater initial abundance of shallow and slow water across all flow stages in the main stem Missouri and potentially increase the rate of chute development.

However, this design option has the potential to increase construction costs and there is uncertainty as to whether it would be effective at reducing chute development timeframes.

Dredging of backwaters
As backwaters age, there is the potential they may fill with sediment and require periodic dredging of either the inlet structure, the backwater itself, or both. If backwaters are too shallow or lose their connection to the river, they may cease to attain the desired biological or physical objectives. The cost for maintenance dredging of a backwater is approximately $_ per acre.

Removal of additional rock from structures controlling ultimate width at bank notches and chutes
In order to construct chutes or widen the river, structures (revetted banks and dikes) used to channelize the river under the Bank Stabilization and Navigation Project are typically altered either by lowering them or removing a section of them. When natural development of chutes or river top-width widening projects is being restricted by these structures, they may be further altered to permit achievement of Objective 3. The cost to alter these structures is anticipated to be approximately $_ per structure.

Lessen slopes on banks of chutes and backwaters to provide additional access to floodplain
Part of Objective 3 includes increasing the lateral connection of created habitat to the floodplain. While backwater projects are typically constructed to the ultimate desired configuration (including size, shape and side slopes), chutes are often constructed as "pilot" channels with the intention of using natural processes to erode banks and establish the desired side slopes. If a chute is not developing as desired and has steep cut banks in some areas, side slopes may be lessened on the banks to allow access to the floodplain. The cost to alter these side slopes in anticipated to be approximately $_ per acre (per foot?).

Add structures to encourage chute meandering, scour hole creation, erosion and deposition
Under Objective 3, chutes are intended to develop over time and meander through natural cut and fill processes. In instances where a chute is not developing as desired, structures may be added to a chute to direct the flow to encourage these processes. The cost for these structures is anticipated to be approximately $_ per structure.

Potential Future Management Actions
The following sections describe management actions that are not currently proposed for implementation due to a variety of circumstances, but may be available for implementation in the future or warrant further investigation of potential costs and benefits.

Habitat projects constructed to final width
Although a few chutes have been constructed to their desired final width, many chute projects and river top-width widening efforts seek to use the river's energy to develop the projects over time. If we are seeing significant delays in the response time for development of these projects, future projects may look at the cost of constructing projects to their ultimate width and configuration.

Restoration of confluence areas
Confluence areas are important habitat areas for many fish species as they represent dynamic areas where a combination of physical and biological gradients occur. Many of the Missouri

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River tributary confluence areas are currently altered or engineered in some way. Although such a project has not yet been undertaken, in the future, these confluence areas may be restored through the removal of control structures or some other means to improve these areas.

Flow Modifications through River Operations
Currently, flow modifications to either create or modify SWH that are outside of the current Master Manual preferred alternative are not proposed. However, one ongoing study, the Missouri River Ecosystem Restoration Plan, may explore opportunities to adjust the operation of the Missouri River in ways that could aid in meeting the SWH objectives.

Actions on tributaries
While the Corps does not currently have authority to undertake actions on tributaries to the target segments of the Missouri River, the Missouri River Ecosystem Restoration Plan is authorized to look at the prospect of expanding management actions to tributaries as part of that study.

Monitoring and Assessment

Several sources of information will be used to evaluate SWH performance. The primary information sources will be the Habitat Assessment and Monitoring Program, the Pallid Sturgeon Population Assessment Program, and focused investigations. For each objective, the strategy for monitoring and assessment is described for each type of habitat project (i.e. chutes, backwaters, main channel structure modifications). This section includes general descriptions of the monitoring required to assess progress towards objectives. Development of detailed monitoring strategies and sampling designs will be initiated once the draft AM Strategy has undergone reviews. These plans will be included as appendices to this document once they are developed.

System-wide responses of pallid sturgeon and other target fishes
Objective 1.1: Increase survival and recruitment of free embryos to exogenously-feeding larval pallid sturgeon
Performance Metrics: Catch rates of larval and YOY pallid sturgeon, pallid population size structure

Objective 1.2: Increase survival and recruitment of YOY pallid sturgeon to age 1
Performance Metrics: Catch rates of YOY and age 1 pallid sturgeon, pallid population size structure changes over time, changes in growth/condition over time

Objective 1.3: Increase survival and recruitment of larval, YOY, and small-bodied big river, native fishes
Performance Metrics: Catch rates of young and small-bodied native fishes, changes in size structures of native fish populations over time, changes in growth/condition over time

Objective 1.4: Restore a self-sustaining population of pallid sturgeon
Performance Metrics: Pallid sturgeon population size structure changes over time, pallid sturgeon abundance over time

Population responses of pallid sturgeon and other native fishes, excluding larval fishes, will be tracked on a larger scale over a long time period as part of the Pallid Sturgeon Population

Assessment Program (PSPAP). If SWH projects are addressing population bottlenecks and benefitting young and small-bodied native fishes then populations of these fishes are expected to show a response over time which will be seen in the PSPAP. The Population Assessment and Monitoring Program can provide trend data for catch rates and length frequency distributions of target fishes. Power analyses indicate that PSPAP data could detect population changes in the time long-term time frames relevant to SWH creation actions (Wildhaber et al. 2011). The PSPAP is not designed to detect short-term changes or determine cause-effect relationships. Population estimates for pallid sturgeon are currently underway for the lower Missouri River and will be available in late 2012. Additional monitoring efforts/focused investigations will be necessary to evaluate larval/YOY fish abundance over time.

Shallow water habitat creation and distribution

Objective 2.1: Increase abundance of shallow water habitat

Performance Metric: Acres of SWH

Several methods for enumerating SWH acres were evaluated during the 2010 SWH accounting effort (Jalili and Pridal 2010), however, a single and consistent method of quantifying SWH still needs to be developed. In general, acres of created habitat are calculated using numerous data sources including limited extent surveys extrapolated to all projects and GIS measurements using the best available aerial photos at each site. Accounting has been based on the general depth (<5 feet) criteria specified in the BiOp with velocities modeled at a subset of bends and extrapolated to the rest of the river. Three numbers were calculated for created SWH. "Minimum" acres represent the amount of SWH present initially following construction. "Current" acres are used in tracking progress toward BiOp targets and represent the amount of SWH currently present (minimum plus acres that have developed as a result of management actions), and "anticipated future acres" represent the maximum acreage expected once habitat development has fully progressed (for example, once a chute has reached maximum design width or once a bank notch has widened the River to extent allowed). All three numbers are reported at median-August flow levels consistent with the direction in the BiOp. Tracking these three numbers will aid in evaluation of habitat development, forecasting anticipated future acres, and eventually assessing validity of these projections.

In the future, SWH accounting criteria and targets may be refined based on increased knowledge of habitat needs to address limiting factors for pallid sturgeon and other native fishes as well as increased knowledge gained by evaluating hypotheses related to the CEM (Appendix A). In addition, future accounting efforts in Kansas City and Omaha Districts will utilize the same methodology to aid in the compilation and interpretation of results.

Table 2. Acres of constructed shallow water habitat reported in the 2010 accounting effort.

	Current	Minimum	Anticipated future acres

Omaha District			
Chutes and revetment chutes	572	348	659
Backwaters	413	367	481
Main-channel modifications	312	421	840
Kansas City District			
Chutes and revetment chutes	345	171	450
Main-channel modifications	1815	1202	4799
Total	3447	2509	7229

There are two key questions related to Objective 2.1. Where are habitat creation efforts in relation to BiOp targets? Are created SWH acres sufficient to produce the desired biological response? The first question will be tracked annually by comparing estimates of created acres ("created acres currently present") to the BiOp timeline (Figure B). The second question will become increasingly relevant as the BiOp target is approached in 2024. It may take at least this long to determine if the BiOp target acreage is appropriate to achieve biological objectives, especially related to pallid sturgeon and other native fishes (see Objective 1).

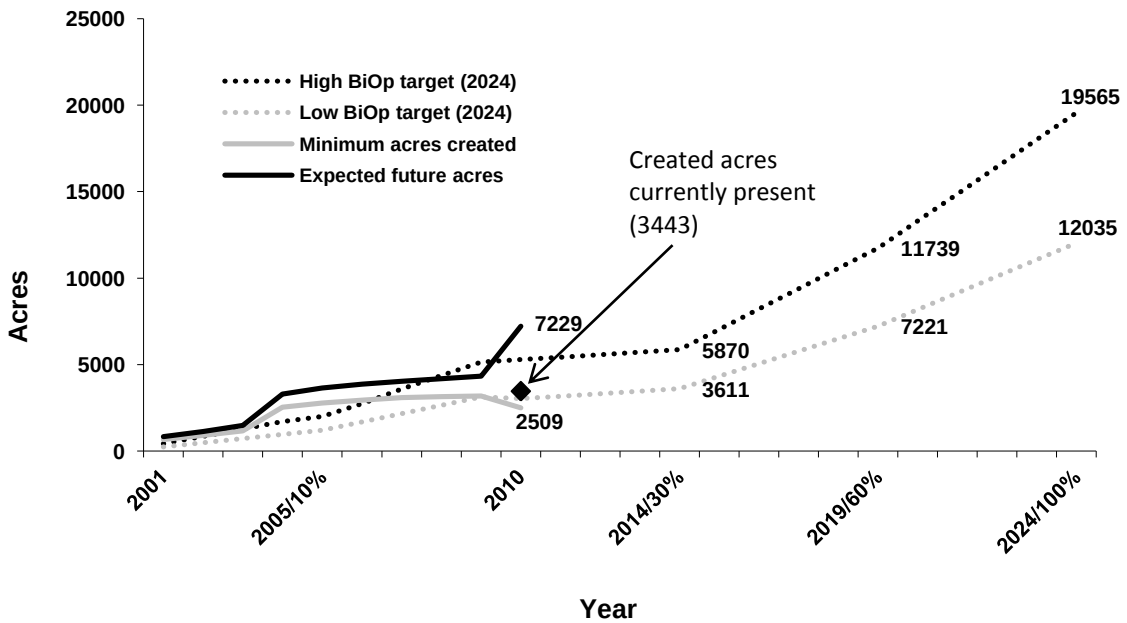

Figure P: Estimated SWH acres created (minimum, current, expected future) in relation to BiOp targets.

How is success determined? Success for this objective will be determined by tracking the current acreage and its progress towards the acreage target. However, issues regarding the projected future acreages, the timeframe for achievement, the acreage target itself, and the incorporation of qualitative metrics will require additional discussions amongst the USACE and FWS. Also, as more information becomes available on biological responses, including pallid sturgeon recruitment, target acreages may need to be reevaluated.

Objective 2.2: Distribute SWH amongst target segments

Performance Metric: Acres of SWH per target river segment

This objective addresses how SWH projects are distributed on the River. For example, should projects be distributed evenly, in complexes, near tributaries, in large tracts versus smaller tracts, etc. The BiOp lists approximations of SWH acres that were present from Sioux City to St. Louis. As part of the 2010 SWH accounting effort (Jalili and Pridal 2010), two methods were used to refine those estimates - an extrapolation of past HAMP data and an evaluation using GIS. Both methods resulted in similar counts (Table 2). These counts may provide a more accurate estimate of the current distribution of SWH as it was developed from a combination of physical measurements and 2-D hydraulic models and did not extrapolate broadly across segments.

Specific biological justifications for project prioritization will be incorporated as information becomes available from focused investigations. For example, if it is determined that SWH near confluences of large tributaries is important to pallid sturgeon then those areas would receive higher priority. While some inferences may be gained from monitoring efforts, addressing these uncertainties will require focused investigations.

Table 3: Estimates of shallow water habitat acreages currently present as determined by two methods and compared to base acres listed in the BiOp.

River segment	Acres/mile (HAMP)	Acres/mile (GIS)	Acres/mile (BiOp est.)
12 – Sioux City to Platte River	4.8	5.6	1.8
13 – Platte to Kansas River	6.3	9.7	4.6
14 – Kansas to Osage River	17.8	17.1	4.6
15 – Osage River to mouth	20.8	18.4	5

How is success determined? Currently, success is based on how well distribution of projects mirrors the SWH targets for each segment. There are many constraints, however, which also influence project location. Land availability and funding are often overriding factors when prioritizing projects. Again, this approach may be altered as information becomes available regarding the biological implications of SWH distribution, in particular relative to pallid sturgeon needs.

Physical characteristics of created shallow water habitat

Objective 3.1: Emulate depth and velocity distributions of best-achievable and/or historic habitats

Performance Metrics: Depth and velocity distributions

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Objective 3.2: Emulate substrate size composition found in best-achievable habitats
Performance Metrics: Substrate size distributions

Objective 3.3: Emulate the entrainment/retention of large woody debris found in best-achievable and/or historic habitats
Performance Metrics: Abundance of large woody debris

Objective 3.4: Increase lateral connection of created habitat between the Median August flow level and the Ordinary High Water Mark
Performance Metrics: Elevation profiles, wetted area/river stage relationships, lateral movement of bank

These objectives address changes in physical habitat which occur as a result of SWH projects. Expected changes to physical habitat vary somewhat depending on project type and, therefore, will need to be evaluated differently for chutes, backwater, and main-channel projects. Measures of success will be determined by a combination of the following depending on project type: comparisons of constructed habitats to best-achievable habitats and/or historic conditions; comparisons of constructed habitats to mainstem river habitats; and comparisons among constructed habitats of different designs, ages, and locations.

In comparing physical metrics between best-achievable sites/historic conditions and created sites, success will be based on degree of similarity (i.e. how well do the constructed sites emulate best-achievable/historic sites). Best-achievable sites used for comparison will represent the best examples of SWH available based on fish use and professional input. Historic comparisons will be attempted similar to Latka et al. 1993. Although it is true that the best SWH examples on today's river are different than historic habitats, they do represent a reasonable target that can also be evaluated. Comparisons to historic conditions, when possible, will also be important to understand how well management actions are restoring conditions under which the fish evolved and to better understand the degree of dissimilarity between best-achievable and historic conditions. In addition to comparisons with best-achievable sites/historic conditions, created sites will be compared to the mainstem to determine whether they are providing habitats with the desired diversity and contrast to conditions already present. Because the age and design of habitat projects vary, comparisons among similar projects of varying ages and designs will help better understand habitat development rates and which design factors are most beneficial.

Chutes (including revetment chutes)
Evaluation of chutes will focus on comparing physical metrics between constructed chutes and best-achievable chutes to determine if constructed chutes increasingly emulate their natural counterparts over time. Comparison of many constructed chutes of varying ages over time will allow for better evaluation of whether habitat progression is occurring as desired and at what rate. Comparisons will also be made between constructed chutes and the main channel to further determine whether constructed habitats are providing physical attributes that are currently rare. The primary physical metrics used to evaluate chutes will be depth and velocity distributions, wetted area/stage relationships, substrate diversity, and abundance of large woody debris. Because habitat change can occur slowly, information on each of the physical metrics will be collected on a three year rotation for all constructed chutes and selected best-achievable chutes. Extreme water events or modifications to projects may result in additional sampling.

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A key component of evaluating chute development will be comparisons of constructed chutes to best-achievable chutes. Selection of best-achievable chutes will be based on habitat complexity metrics, fish use data, and professional input (Table 3). The intent is to use best-achievable chutes as guides to assess the development of constructed chutes not to duplicate a particular chute or to suggest that all chutes need to look the same.

Table 4: List of potential reference chutes between Sioux City and St. Louis.

Chute	Length	River miles
Lisbon	2.25 miles	218-215
Cranberry Bend	1 mile	282-280.5
Little's Island	2 chutes – 1 mile and 3 miles	11-8.5
Pelican Island	3.5 miles	16-10.5

Frequency distributions similar to that shown in Figure C will be used to evaluate depth, velocity, substrate, and lateral connectivity. These distributions can then be used to compare habitats (e.g. similarity indices) and evaluate changes over time (Figure D) to determine if chutes are progressing in the desired direction or suggest modifications to projects to further direct chute development. Not only will individual chutes be monitored over time to track change, many chutes of differing ages will be compared to make an assessment now of how physical metrics are changing over time.

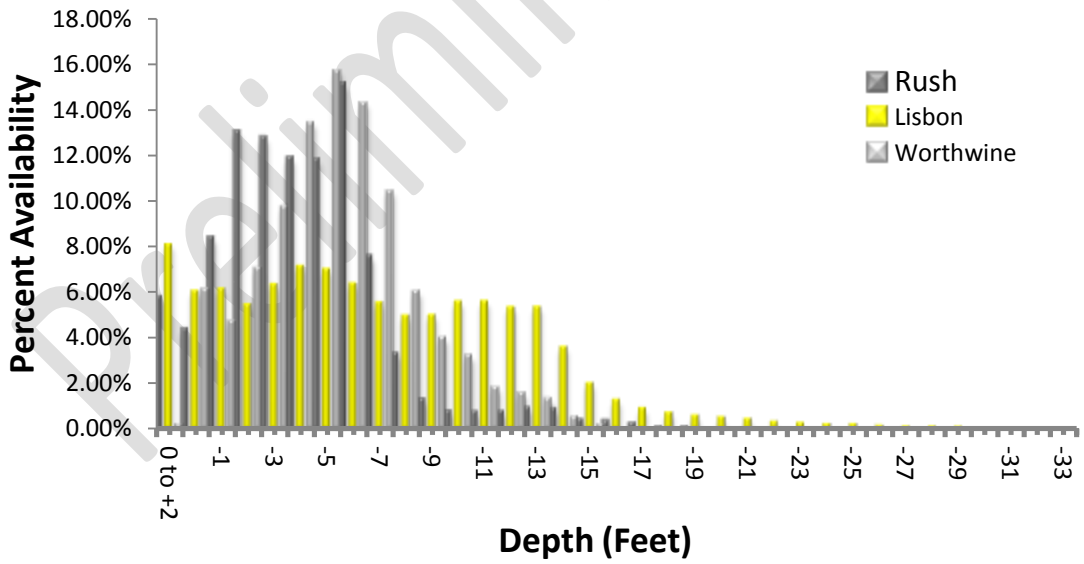

Figure Q: An example of depth distributions of constructed and best-achievable chutes. Similar frequency distributions will be used for other metrics as well.

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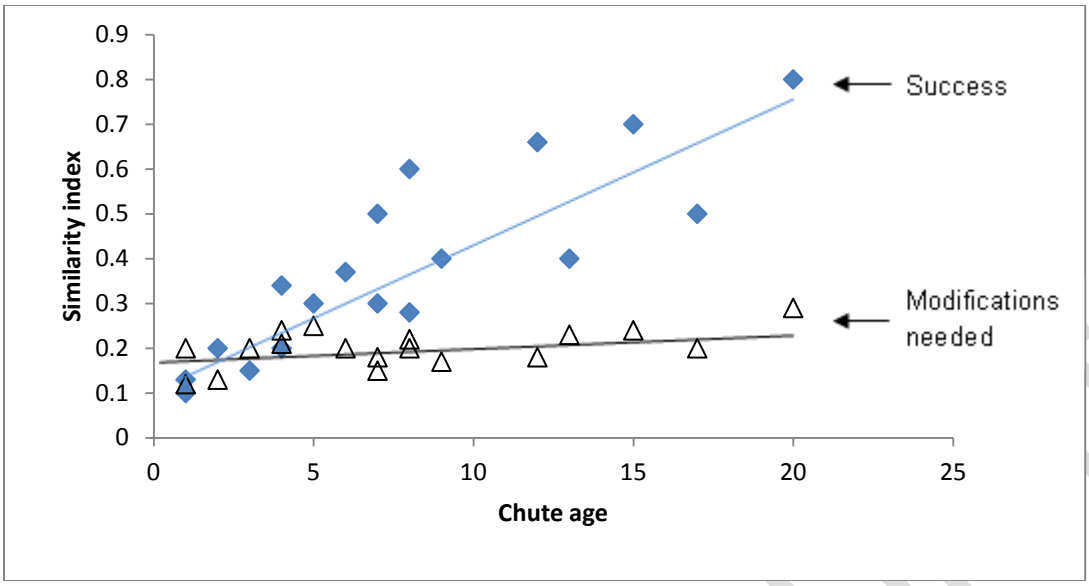

Figure R: Hypothetical similarity indices between best-achievable chutes and created chutes of different ages (index of 1 indicates identical characteristics and index of 0 indicates no similarity). This is a hypothetical graph and could pertain to any of the performance metrics. A similar analysis can be used to track development of an individual chute over time. Where possible, similarity to historic conditions should also be determined as context for the relative condition of best-achievable habitats.

Proportional Similarity Indices (PSI) can be calculated to compare similarity between frequency distributions as follows:

where p_i and q_i are the relative frequencies for constructed and best-achievable habitats in class i; the Sum function sums over all classes. The result is a value between 0 (no similarity) and 1 (identical distributions).

How is success determined? As chutes age, they are expected to increasingly emulate best-achievable chutes (i.e. older chutes should look more like best-achievable chutes than do younger chutes). A comparison of similarity between constructed chutes and best-achievable chutes should therefore show a positive relationship with chute age. This information will also provide an average rate of progression which can be used to compare performance of individual chutes.

Depth and velocity distributions (3.1) - Distribution data similar to that shown in Figure C can be used to describe depth and velocity data and evaluate changes over time (Figure D) to determine if chutes are progressing in the desired direction or suggest modifications to projects to further direct chute development. Bathymetric data will be collected on all constructed chutes and selected best-achievable chutes once every three years. Additional data collection may occur due to high water events, planned modifications, etc. Bathymetric information will be evaluated based on the 50% exceedance August flow duration (either measured at this time or calculated based on index flows). Data collection needs to occur at flows high enough to allow boat access to all SWH. Velocity data will be collected at selected constructed and best-achievable chutes.

Velocity data will be collected along transects with an Acoustic Doppler Current Profiler (ADCP).

Lateral connectivity (3.4)

When chutes are constructed, the banks are often vertical and high as a result of construction methods and elevation of surrounding lands. These conditions are similar to what is currently found in the mainchannel. As a result, SWH acreage changes little, and may even decrease, as river stage increases within the range of median August flows to the ordinary high water mark. This is opposite of what occurred historically when SWH acreage increased as river stage increased. Best-achievable chutes and historic side-channels typically have/had sloped banks and a variety of surrounding elevations which create increasing areas of inundated land as river stage increases (Figures E and F). These conditions are created over time by natural erosion and deposition processes. Allowing these processes to act in created chutes is necessary to create this lateral connectivity. Chute design, construction methods, and site selection can all play a role in promoting these natural processes. To evaluate whether constructed chutes are developing lateral connectivity, elevation profiles of adjacent lands will be compared between constructed and best-achievable chutes over time. Elevation data will be collected with LiDAR during low water periods. Bathymetry data collected during high water events may also be used.

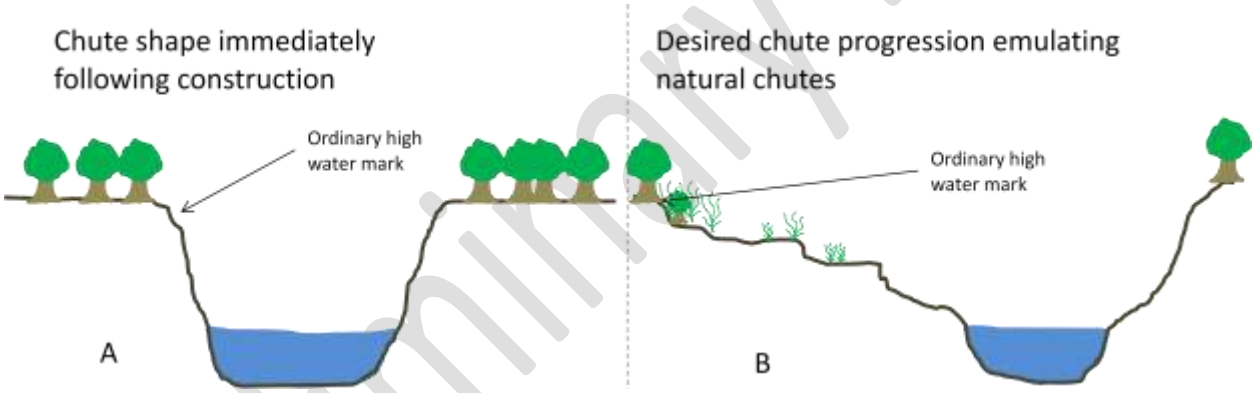

Figure S: Diagram showing the lack of lateral connectivity in newly-created chutes and the main channel (A) and the increased lateral connectivity seen in best-achievable chutes and expected to develop over time in created chutes (B).

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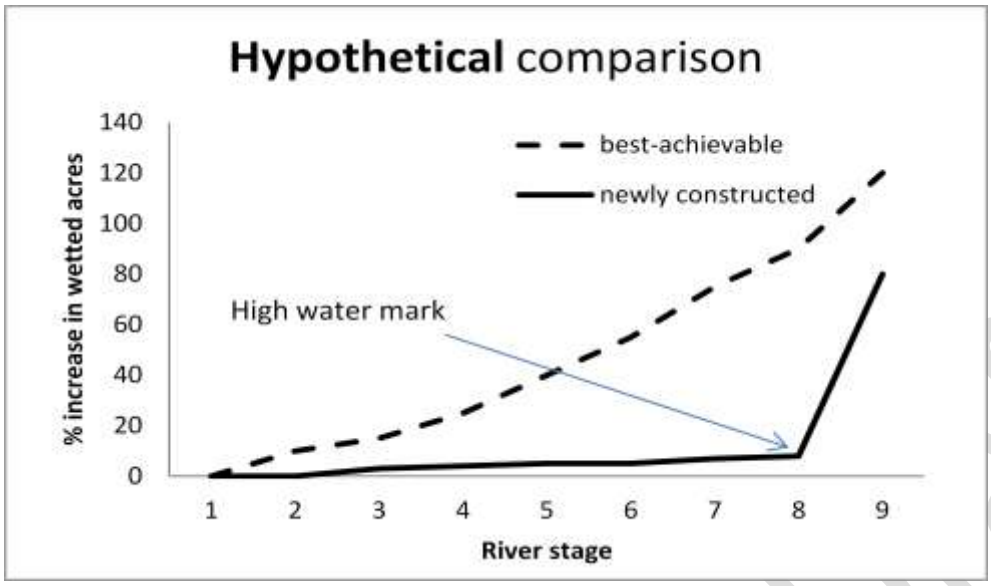

Figure T: A hypothetical comparison of lateral connectivity (wetted area/river stage) between best-achievable and constructed chutes.

How is success determined? Similarity in normalized lateral connectivity (elevation profiles, area/stage relationships) between created, best-achievable, and historic chutes will be evaluated over time. In order to compare amongst side-channel chutes of varying sizes, chutes will be normalized for surface area at the median August flow. If similarity increases over time (see Figure C), the desired progression is occurring. If progression is occurring very slowly or not at all, modifications may be necessary to further promote desired hydrologic processes.

Substrate size distribution (3.2)

As a result of diverse water velocities and erosional and depositional processes, chutes are expected to contain a diversity of substrates including an increased prevalence of fine substrates resulting from increased prevalence of slow water. Substrate size distributions can be affected by the chute entrance as well as hydrogeomorphic processes within the chute. Substrate size is an important determinant of habitat use by many benthic fishes, can be used as a surrogate for water velocities, and is useful in interpreting benthic invertebrate data. Substrate size distribution will be compared between constructed and best-achievable chutes to determine degree of similarity.

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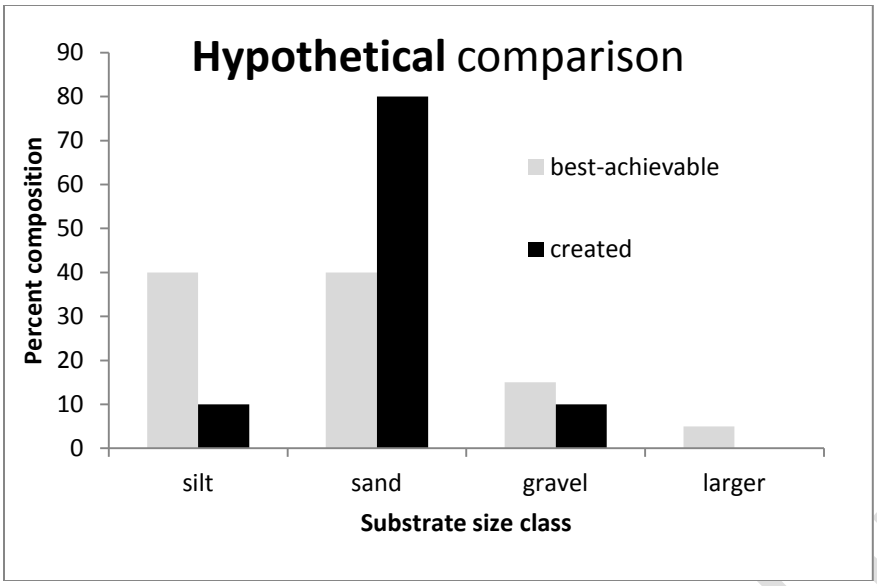

Figure U: A hypothetical comparison of substrate sizes between best-achievable and constructed chutes.

How is success determined? Similarity in substrate size distribution will be compared between constructed and best-achievable chutes over time. If they become more similar, the desired progression is occurring. If progression is occurring very slowly or not at all, modifications may be necessary to further promote the desired changes in substrate size distributions.

Abundance of large woody debris (3.3)
Increasing abundance of woody debris in created habitats will depend on creating the depths and velocities necessary to allow entrainment and retention of woody.

How is success determined? Initially, constructed chutes may not retain large woody debris because of steep banks, fast water, and lack of shallow water. Over time, the chute's ability to retain large woody debris should increase and the abundance of woody debris should become more similar to abundance of woody debris in best-achievable chutes and historic conditions (Figure H).

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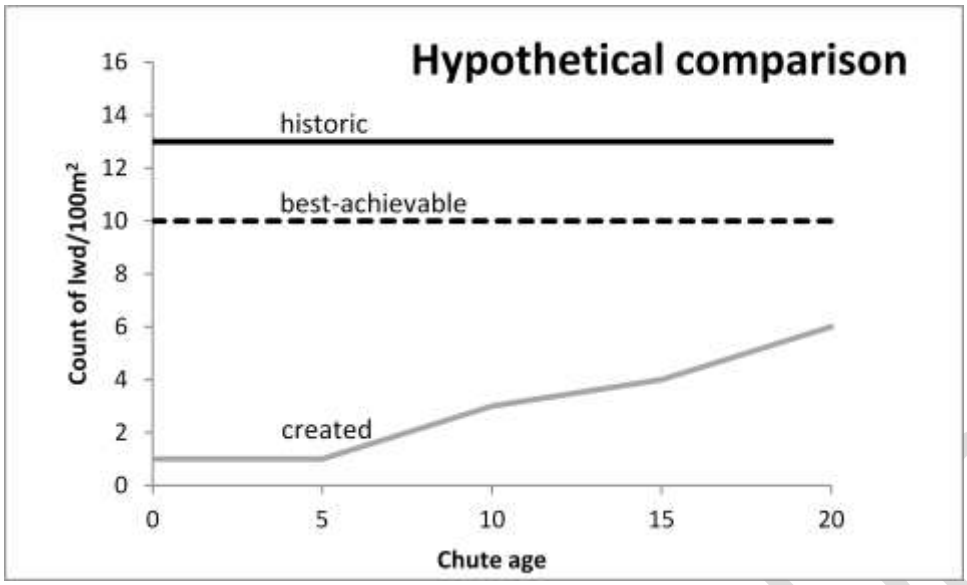

Figure V.- Hypothetical graph showing abundance of large woody debris in a constructed chute over time compared to historic abundance and abundance in best-achievable chutes. This graph depicts the desired progression (i.e. abundance of woody debris becomes more similar to abundances found in best-achievable chutes and in the historic MO River.

Backwaters

Backwaters are expected to provide areas of little or no water velocity and predominantly shallow depths. Most created backwaters will also be expected to maintain connection to the river at low flows to provide access to young fish during critical rearing periods from mid summer through winter. It is important that the design minimize the need for dredging to maintain the backwater and its connection to the river. Key physical characteristics include degree of connectivity to the river (or chute), depth distributions, size, and lateral connectivity. These physical characteristics are important for tracking rate of siltation and they will affect productivity, dissolved oxygen levels, potential for fish kills, and accessibility/suitability for native fishes. Because so few natural backwaters currently exist which maintain connectivity to the river, the primary methods of evaluation will be comparing backwaters of different designs to determine which design options produce desired results.

Depth and velocity distributions (3.1)

Monitoring of water depth will focus on rate of siltation, maintenance of connectivity to the river, and depth distributions. Backwaters may become shallower over time due to siltation but the rate at which this occurs is important for cost projection and adaptive management. The rate of siltation needs to be documented over time for individual backwaters and compared among backwaters of different designs. Routine creation of bathymetric maps of each backwater will be the primary monitoring approach. Bathymetric maps will be created for each backwater on a three year rotation. Bathymetry data should be collected during high water to ensure access to as much of the backwater as possible. Water velocity is generally not an important metric for evaluating backwaters – water velocities will be at or near zero. Water velocities may be important for evaluating performance of the connection to the river.

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How is success determined? Comparisons among constructed backwaters will help determine designs which minimize rates of siltation and maintenance costs. Information collected to evaluate biological response objectives will help determine how backwater depths and connectivity to the river affect productivity and fish communities. This information will be used to design future projects and propose improvement to current projects.

Lateral connectivity (3.4)
Surrounding elevations of constructed backwaters are important since they determine lateral connectivity and extent of inundated vegetation as river stage rises. Maximizing inundated acres as river stage between the median August flow and the ordinary high water mark increases is important and will be a measure of backwater quality. Surrounding elevations can be determined from LiDAR or bathymetric mapping during high water.
How is success determined? Unlike constructed chutes which are expected to develop over time, constructed backwaters must be constructed to near desired condition and over time will fill in. The degree of lateral connectivity which can be achieved at a proposed site along with the related cost will be an important design consideration. Understanding the relationship among lateral connectivity, flows, and biological objectives will be important in designing backwaters in the future.

Substrate diversity (3.2)
Substrate diversity is not an important metric for evaluating backwaters. Because there is little or no current in backwaters, substrates will be predominantly silt.
Abundance of large, woody debris (3.3)
Recruitment of large woody debris into backwaters will depend on high flow events which introduce woody debris or on input from surrounding land.
How is success determined? Woody debris will be counted initially following backwater construction or as soon as possible. Woody debris abundance will then be tracked over time to determine if recruitment is occurring. The expectation is that woody debris abundance will increase in years following construction.

Main channel habitats (bank notches and dike notches)
Initial assessments of monitoring data have indicated that notching of dikes has resulted in little detectable change in fish use (Schapaugh et al. 2010; Schloesser ****) or has potentially had negative impacts to some species (Ridenour 2008). These studies have looked at the effect of dike notches at the bend level and have not attempted to differentiate among notch types. These analyses also indicated that additional information on physical and biological characteristics of these habitats, including degree of habitat change resulting from notching, are needed to interpret these results. Evaluation of physical habitat changes would focus on determining which notch sizes, notch elevations, and notch locations most emulate the physical conditions present within the highest quality reaches currently found on the River. Future dike modifications should be performed on treated HAMP bends **while maintaining control bends as is**. This will permit continued use of the HAMP BACI design to evaluate responses to dike notching and continue to increase the treatment effect by additional modifications to treated bends. Information should also be collected in treated bends prior to additional modifications to allow evaluation of the resulting changes. There may be significant differences in the benefits of notching in upstream reaches compared to downstream as the length of dikes and river width increases. Evaluation of

main-channel modifications should be stratified by location (for example: upstream of the Kansas River).

Depth and velocity distributions (3.1)
Dike notches are intended to emulate braided flow and in some cases increase river top-width. Future dike modifications will seek to emulate the depth and velocity distributions of reaches with increased habitat complexity and increased abundance of target fishes and size classes. Depth and velocity distributions will be taken at selected dikes and bank notches at median August flows.

How is success determined? One measure of success will be the similarity between depth and velocity distributions between best-achievable sites and treated HAMP bends. Where possible, comparisons to historic depth distributions will be made to evaluate relative quality of best-achievable sites. In the case of bank notches, a measure of success will be the extent that the river top-width increases (e.g. does it reach design width).

Lateral connectivity (3.4)
Bank and dike notches should increase lateral connectivity by eroding banks and creating increased elevation diversity of banks and sand bars.
How is success determined? One measure of success will be the similarity in bank slopes and sand bar elevations compared to best-achievable reaches as well as historic conditions.

Substrate size distribution (3.2)
Substrate size influences habitat use by benthic fishes and could be an important factor in preferential use of some river reaches by target fishes.
How is success determined? Substrate size distributions will be compared between modified reaches and best-achievable reaches. Success will depend on whether dike modifications result in increased similarity of substrate sizes between modified reaches and best-achievable sites.

Table 5: Physical metrics and periodicity of sampling for evaluating chutes, backwaters, and main channel structure modifications. Specific periods will be determined as part of detailed sampling design.

	Chute	Backwater	Main channel Structure mods
Depth	All constructed chutes (periodic)	All constructed backwaters (periodic)	HAMP bends (periodic)
Velocity	20% of chutes (periodic)	N/A	HAMP bends (periodic)
Lateral Connectivity	All constructed chutes (periodic)	All constructed backwaters (periodic)	N/A

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Substrate size	All constructed chutes (periodic)	N/A	HAMP bends (periodic)
Large woody debris	All constructed chutes (periodic)	All constructed backwaters (periodic)	Bank notches (periodic)

Project-scale biophysical and biological responses
Objective 4.1: Increase abundance and species diversity of native larval, young-of-year, and small-bodied fishes at project sites

Performance Metrics: Abundance of target fishes and size classes, fish community diversity

Objective 4.2: Provide appropriate feeding/nursery areas for larval/YOY, and small-bodied fishes by creating SWHs where 1) water warms more quickly and reaches higher temperatures than currently found in main channel, 2) organic matter retention rates are higher than in the main channel, 3) terrestrial vegetation establishes in the transition zone between water line at median August flow and the ordinary high water mark, and 4) zooplankton/benthic invertebrate abundance is higher than in the main channel
Performance Metrics: 1) water temperature, 2) total organic carbon in sediment, 3) vegetation abundance between median August flow and Ordinary High Water mark, 4) benthic macroinvertebrate abundance and composition.

Chutes (including revetment chutes)
Abundance and species diversity of native larval, young-of-year, and small-bodied fishes (4.1)
Evaluation of chutes will focus on determining whether they are developing areas within them which are retaining larval, YOY, and small bodied fishes.
How is success determined? Comparing catch rates of target species and size classes between constructed chutes and best-achievable chutes will determine whether constructed chutes are emulating their more natural counterparts or at least progressing in that direction. Comparisons will also be made between constructed chutes and the main channel to further determine whether created habitats are providing areas which increase retention of young fishes. Although comparisons with best-achievable habitats will provide a meaningful comparison, even the best-achievable habitats may not achieve the level of retention needed to recover target species. Evaluations of hypotheses associated with the CEM (Appendix A) will allow for assessment of whether SWH creation alone can achieve desired biological responses.

Provide appropriate feeding/nursery areas for larval/YOY, and small-bodied fishes (4.2)
Chutes are expected to provide areas of quality nursery habitat for larval, YOY, and small bodied fishes. For example, areas within a chute should provide increased organic retention and secondary productivity. These areas, which should also be retaining young fishes, should be providing the food resources those young fishes need at the right time.
How is success determined? One measure of success will be whether project-level biological responses (e.g. increased organic retention, increased invertebrate abundance) are occurring

within created chutes and are similar to those found in best-achievable chutes (i.e. those which have highest abundance of target fishes). It is expected that as chutes develop, biological responses will increasingly emulate best-achievable chutes. Another measure of success will be whether created chutes are providing higher quality nursery areas than already present in the adjacent river. Further, success will be determined by whether areas within a chute are providing the desired nursery habitat conditions at the proper times and locations based on presence of target species and life stages. Achieving the desired project-level biological responses will be highly dependent on the interaction of the created habitat with flows. Evaluations of these project-level metrics across a range of flows will allow for assessment of whether current flow regimes will allow SWH creation to achieve desired biological responses. Water quality parameters, including water temperature, turbidity, and DO will be monitored as covariates, at little cost, to help interpret primary and secondary productivity metrics.

Backwaters

Abundance and species diversity of native larval, young-of-year, and small-bodied fishes (4.1)

Evaluation of backwaters will focus on determining whether they are utilized by larval, YOY, and small bodied fishes.

How is success determined? Comparing catch rates of target species and size classes between constructed backwaters and main channel habitats will help determine whether backwaters are accessible at the right times and whether they are being utilized by target species and size classes. Evaluations of hypotheses associated with the CEM (Appendix A) will allow for assessment of whether SWH creation alone can achieve desired biological responses.

Provide appropriate feeding/nursery areas for larval/YOY, and small-bodied fishes (4.2)

Backwaters are expected to provide areas of quality nursery habitat for larval, YOY, and small bodied fishes. Backwaters should be providing the food resources young fishes need at the right time.

How is success determined? One measure of success will be whether the desired project-level biological responses (e.g. increased organic retention, increased invertebrate abundance) are occurring within created backwaters and therefore providing higher quality nursery areas than already present in the adjacent river. Comparisons of growth and condition of target fishes collected in backwaters compared to other habitats will help determine whether backwaters are providing higher quality nursery habitats. Achieving the desired project-level biological responses will be highly dependent on the interaction of the created habitat with flows. Evaluations of these project-level metrics across a range of flows will allow for assessment of whether current flow regimes will allow SWH creation to achieve desired biological responses. Water quality parameters, including water temperature, turbidity, and DO will be monitored as covariates, at little cost.

Main channel habitats (bank notches and dike notches)

Abundance and species diversity of native larval, young-of-year, and small-bodied fishes (4.1)

Evaluation of created main channel habitats will focus on determining whether they are developing areas within them which are retaining larval, YOY, and small bodied fishes.

How is success determined? Comparing catch rates of target species and size classes between created habitats and best-achievable habitats will determine whether created habitats are emulating their more natural counterparts or at least progressing in that direction. Catches of

larval/YOY fish will be compared at the bend level between notched dikes and un-notched dikes to determine whether main channel modifications are producing habitats more suitable to target species and age classes. Comparisons will continue using HAMP bends (control and treated) and will occur once every three years. In addition, similar sampling will occur in river reaches believed to represent the best habitat available to verify that these locations are preferentially used by target species and to use as a comparison and guide for main channel modifications. It will be important to compare both total catch and catch rates because an increase in quality habitat could result in more habitat to sample (and more fish) but no change in catch rates. Although comparisons with best-achievable habitats will provide a meaningful comparison, even the best-achievable habitats may not achieve the level of retention needed to recover target species. Evaluations of hypotheses associated with the CEM (Appendix A) will allow for assessment of whether SWH creation alone can achieve desired biological responses.

Provide appropriate feeding/nursery areas for larval/YOY, and small-bodied fishes (4.2)
Created habitats within the main channel are expected to provide quality nursery areas for larval, YOY, and small bodied fishes. These areas, which should be retaining young fishes, should also be providing the food resources those young fishes need at the right time.
How is success determined? One measure of success will be whether project-level biological responses (e.g. increased organic retention, increased invertebrate abundance) are occurring within created habitats and are similar to those found in best-achievable habitats (i.e. those which have highest abundance of target fishes). It is expected that as habitats develop, biological responses will increasingly emulate best-achievable habitats. Another measure of success will be whether created habitats are providing higher quality nursery areas than already present in control habitats (those where habitat creation actions have not occurred). Further, success will be determined by whether created habitats are providing the desired nursery habitat conditions at the proper times and locations based on presence of target species and life stages. Achieving the desired project-level biological responses will be highly dependent on the interaction of the created habitat with flows. Evaluations of these project-level metrics across a range of flows will allow for some assessment of whether current flow practices will allow SWH creation to achieve desired biological responses. Water quality parameters, including water temperature, turbidity, and DO will be monitored as covariates, at little cost.

Priorities
Priorities for monitoring efforts are listed below. These priorities were derived from both the linkages in the conceptual ecological model and input of the SWH PDT and reflect the most crucial pieces of information for decision-making related to the SWH AM Strategy. Costs are rough approximations based on past efforts and projected levels of efforts required.

1. **Local abundance of larval and YOY pallid sturgeon and other native fish species**

As SWH is hypothesized to benefit larval and YOY pallid sturgeon by providing areas for them to settle out and grow, one of the highest priorities is to determine if this is occurring to a greater degree than in habitats already available. Sampling will determine habitat suitability based on catch rates of larval and YOY pallid sturgeon in all habitats including SWH sites and best-achievable reference sites. During this collection effort, other native fish species would be collected as well. The anticipated cost for this effort is $500,000 per year.

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2. Abundance and size-structure of pallid sturgeon and other native fish populations

The ultimate measure of success for this management action along with other MRRP management actions related to pallid sturgeon will be in terms of population growth rate of non-hatchery-raised fish. In order to determine population trends, a long-term monitoring program of pallid sturgeon is needed (PSPAP). As part of this collection effort, other native fish species will be monitored as well. The anticipated cost for this effort in the target segments is approximately $2,200,000 per year.

3. Abundance and distribution of SWH

Accounting progress towards SWH goals is an important piece of information for decision-making in order to determine the amount of creation needed to meet long-term SWH goals. This effort would likely pull from other data sources but involves processing and potentially some collection of new data such as collection of new aerial photgraphy. The anticipated cost for this effort is approximately $50,000 and would be conducted every three to five years.

4. Depth distributions

Data on depth distributions is needed to assess changes in physical habitat complexity of both created SWH sites and best-achievable sites for comparison against targets. Depth distributions are one of the highest priority pieces of physical information needed to inform decision-making. The anticipated cost for this effort is approximately $400,000 and would be conducted every three to five years.

5. Lateral Connectivity

Lateral connectivity is hypothesized to have many connections between SWH creation and biophysical responses in the conceptual model. Elevation data would be collected from areas adjacent to SWH creation sites and best-achievable sites. The anticipated cost for this effort is approximately $500,000, however, this effort may only need to conducted every 10 years or after a large event on the system.

6. Velocity distributions

Velocity within SWH are anticipated to be closely related to depth of water and flow, however, velocity distributions will likely be collected at a smaller number of sites than depth distributions and other physical data in order to better understand these relationships and to facilitate the development of 2D hydraulic models used in accounting efforts. The anticipated cost for collection and processing of velocity distributions is $500,000 per year.

7. Local abundance of organic matter and benthic macroinvertebrates

Local abundance of organic matter and/or benthic macroinvertebrates are two of the primary hypothesized connections between habitat complexity and growth of larval and YOY pallid sturgeon in the CEM. This data would be collected at a representative sample of created SWH sites and best-achievable sites. The anticipated cost for collection and processing of this data is $100,000 per year.

8. Abundance of large woody debris

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Abundance of LWD is important for fish habitat structure, proliferation of benthic macroinvertebrates, and is an important source of organic input. It is also one of the predictors of both depths and velocities. The anticipated cost for assessing the abundance of LWD is $50,000 per year.

9. Substrate diversity

Substrate diversity is an important variable related to biological metrics such as the abundance of benthic macroinvertebrates, as well as physical metrics such as water velocity. Data would be gathered using either grab samples or scanning technology and is anticipated to cost approximately $50,000 per year.

10. Terrestrial vegetation cover

Extent of establishment of terrestrial vegetation below the ordinary high water would be gathered using visual estimates of percent cover and is anticipated to cost approximately $50,000 per year.

11. Water quality

Many of the water quality parameters (such as dissolved oxygen, turbidity, temperature, etc.) are covariates needed to interpret other monitoring data as well as assess habitat suitability. This information will be collected at very little cost and at the same time as other monitoring efforts. As there is no cost associated with these efforts, priority for funding is low.

Table 6. Summary of Monitoring Priorities and cost estimates

Priority	Monitoring	Frequency of Collection	Anticipated Annual Cost
1	Larval & YOY fish	Annually	$500,000
2	Pallid sturgeon and native fish	Annually	$2,200,000
3	Abundance of SWH	Every 3-5 years	$50,000
4	Depth Distributions	Every 3-5 years	$400,000
5	Lateral Connectivity	Every 10 years	$500,000
6	Velocity Distributions	Every 3-5 years	$500,000
7	Organic matter / Benthic macroinvertebrates	Every 3-5 years	$100,000
8	Abundance of LWD	Every 3-5 years	$50,000
9	Substrate Diversity	Every 3-5 years	$50,000
10	Terrestrial Vegetation Cover	Every 3-5 years	$50,000
11	Water Quality	Every 3-5 years	N/A

Data Storage and Quality Assurance/ Quality Control

Data entry, quality control, and storage standards are currently in place for ongoing monitoring of pallid sturgeon and native fish species populations under the Pallid Sturgeon Population Assessment Program (PSPAP). PSPAP data is collected using standardized two-page data sheets designed for recording all information (e.g., sample site, habitat characteristic, and fish data) which use standardized codes to ensure consistency in the database. A field crew leader is

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responsible for reviewing the data sheets promptly following field data collection efforts to ensure that all codes are complete, accurate, and legible. After all data sheets have been reviewed by the field crew supervisor, the original is submitted for data entry, and a copy of each data sheet will be maintained at the field station. All data is entered into a database via double-blind entry to identify any mistakes that may occur during the process of data entry. Other monitoring efforts will utilize similar protocols.

Frequency of Assessments

Assessments will be conducted on an annual basis and captured in an Annual AM Report. Every five years, additional analyses may be conducted on an as-needed basis (see section 6.2).

Documentation

Data and analyses will be reported on an annual basis as part of an Annual AM Report (see section 6.2).

Investigations

The following sections describe additional focused investigations that will aid in addressing uncertainties associated with the management actions that cannot be fully addressed through the proposed monitoring efforts. These investigations are intended to be shorter term than monitoring efforts and have defined end-dates. Rough order of magnitudes estimates of cost and timeframe for each investigation are included. Investigations are listed in order of priority.

1. **Determine the locations of larval pallid sturgeon**

This investigation would be a target effort to determine locations of larval pallid sturgeon in the Missouri River, and potentially the Mississippi River, to determine the types of habitat that are being occupied, the qualities these habitats exhibit, and the spatial distribution of larval pallid sturgeon. This investigation would assist in addressing uncertainties related to the habitat needs of larval pallid sturgeon and their distribution and abundance in the Missouri River. This investigation is anticipated to cost approximately $1,500,000 over 4 years.

2. **Develop a set of reference conditions for comparison of created sites to best-achievable habitats and historic conditions**

Many of the analyses and assessments described in this AM strategy rely on the use of reference conditions for comparing the development of SWH projects to determine progress towards restoration objectives. This investigation would focus on developing these reference conditions from existing sites on the river using existing data and from historic data. This effort is anticipated to cost approximately $300,000 and be completed in one year.

3. **Investigate fluid interactions around SWH to determine whether larval pallid sturgeon can enter SWH sites and be retained**

This investigation would involve the collection of physical data and development of either two- or three-dimensional hydraulic models for a subset of SWH sites (approximately four) to determine if designs of inlet structures and structure modifications including dike notches are providing the proper conditions to allow drifting larval sturgeon to settle out in SWH at the right time of year. This investigation would assist in answering uncertainties related to the potential

for SWH creation sites to retain larval pallid sturgeon. For the two-dimensional modeling, this investigation is anticipated to cost approximately $250,000 over 2 years. For the three-dimensional modeling, the anticipated cost would be $750,000 over 3 years.

4. Interaction between flows and the availability and functionality of SWH

The benefits of restoring some natural form to the river through SWH creation are not only dependent on changes to channel form but also the interaction with flows. This investigation would seek a more detailed understanding of these interactions needed to achieve biological objectives including changes in availability of SWH at different flow levels, timing and duration of flows and their affects on biological metrics. This would involve the development of a flow-stage relationship for a subset of SWH and best-achievable sites. This investigation is anticipated to cost approximately $300,000 over 2 years.

5. Investigate differences amongst large, clustered, and small SWH sites to address uncertainties regarding the best scale for SWH creation sites

This investigation would involve the collection of additional data from selected large, small and clustered SWH sites, with the potential to pair this investigation with one or more pilot projects, as well as additional data analysis of past data in order to determine if there are differences in biological responses due to the scale of SWH. This investigation would assist in addressing uncertainties related to design characteristics and placement of SWH creation sites. This investigation is anticipated to cost approximately $1,000,000 over 5 years.

6. Investigate potential drift distances for pallid sturgeon produced downstream of Gavins Point dam

This investigation would involve studies to determine the potential drift distances for pallid sturgeon spawned downstream of Gavins Point Dam and would test and potentially validate assumed drift distances developed from studies in the upper Missouri River. This investigation would assist in addressing uncertainties related to the potential for SWH sites in different locations to retain larval pallid sturgeon. This investigation is anticipated to cost approximately $300,000 over 2 years.

7. Determine the relative benefits of different types of SWH sites

This investigation would primarily use existing data to compare the relative benefits amongst different types of SWH sites such as side-channel chutes, backwaters, various types of structure modifications, and new structures. The investigation would include analyses related to the rates of habitat development, physical habitat characteristics, and biological responses. This investigation would assist in addressing uncertainties related to the creation of SWH and the potential benefits to be gained from different types of sites. This anticipated cost for this investigation is approximately $100,000 over 1 year.

8. Investigate the implications of different distributions of SWH amongst target segments

This investigation would use historical data, emerging understanding of pallid sturgeon genetic population structure, drift dynamics, and additional information on the native fish community to improve understanding of optimal distribution of SWH downstream of Gavins Point Dam. The analysis will consider uniform distribution, distribution scaled to channel size, historical

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distribution, and distributions designed to optimize ecological functions within the engineered system. This investigation would assist in addressing uncertainties related to the distribution of SWH creation sites amongst the target segments.

9. Investigate growth rates and feeding requirements of larval and YOY pallid sturgeon.

This investigation would involve lab and field studies to determine optimal and existing growth rates for larval and juvenile pallid sturgeon, compare differences amongst growth rates in lab and field settings and determine the viability and feasibility of using sturgeon growth rates as a potential metric for the SWH AM Strategy. It would also address the food requirements for pallid sturgeon and whether those foods are available in SWH creation and best-achievable habitats. This investigation would help to address the potential benefits of created SWH sites. The anticipated cost for this investigation is approximately $500,000 over 3 years.

10. Determine the amount of SWH that can be restored without impacting the navigation channel

This investigation would address uncertainties related to the amount of habitat that can be restored before too much water is diverted from the main channel and navigation on the system is impacted or no longer possible. This effort would involve development of a model to determine the amount of water under different flow scenarios that could be diverted into SWH sites without negatively impacting flows in the navigation channel using existing data. This anticipated cost for this investigation is approximately $300,000 over 2 years.

11. Investigate the amount of time required for SWH to develop though erosion and deposition processes

There can be a significant lag time (many years, even decades) between the management action of constructing SWH and the desired condition of the habitat. The amount of time needed for development of different types of SWH projects due to hydrogeomorphic processes is somewhat uncertain and depends on flows, project type and design, and location. While this data will be derived from successive years of monitoring SWH creation sites, this investigation would involve a modeling effort in the near-term to determine rates of development under different flow scenarios and for different types of SWH creation sites. This would involve the development of two-dimensional hydraulic model for a subset of SWH sites (approximately four) that incorporates sediment transport and channel morphology. This investigation is anticipated to cost approximately $750,000 over 3 years.

12. Develop a revised quantitative definition of SWH

The clarified definition of SWH adds many qualitative characteristics to the quantitative definition of less than five feet deep and less than two feet per second velocity. This investigation would use existing data to develop quantifiable indices. Existing depth and velocity datasets may be mined to develop quantitative metrics and to compare with existing biological data and expert opinion. The anticipated cost for this investigation is approximately $250,000 over 2 years.

13. Conduct a study to determine important food resources for chub species

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Chub species are hypothesized to be an important food resource for pisciverous pallid sturgeon. However, populations of many native chub species have declined on the Missouri River. This investigation would involve laboratory and field work to determine diet requirements and important food resources for chub species. A follow on analysis would be conducted using monitoring data from the SWH and best achievable sites to determine if these food resources are available or if there are measurable differences amongst different types of SWH sites. The anticipated cost for this investigation is approximately $375,000 over 3 years.

14. Investigate the potential impacts of contaminants in the Missouri River on pallid sturgeon

This investigation would involve determining levels of contaminants in the Missouri River (with either passive or active sampling methodologies) as well as laboratory studies to determine the potential impacts of these contaminants in various concentrations on different life stages of pallid sturgeon.

15. Investigate the potential impacts of SWH sites on invasive species

This investigation would look at the potential for different types of SWH to benefit non-native aquatic species such as carp. Existing data would be used to determine potential trade-offs associated with SWH types and designs regarding undesirable species. The anticipated cost for this investigation is approximately $100,000 over 1 year.

Other potential investigations:
In addition to the prioritized list of investigations above, a number of other potential investigations were identified. These investigations may be added to the list of priorities as the SWH AM Strategy transitions into the implementation phase.

- Investigate system energy inputs (in the form of carbon inputs) in the navigation channel of the Missouri River compared with SWH creation sites and sample sites from other, more natural segments of rivers, such as the Gavins Point segment of the Missouri River and the Yellowstone river.
- Investigate the energetic requirements for larval pallid sturgeon and compare with available resources in different types of SWH.
- Investigate interspecific interactions between shovelnose & pallid sturgeon to determine the potential effects of competition and hybridization and any implications on meeting the SWH AM Strategy's stated objectives. This investigation may also explore the differences between shovelnose sturgeon and pallid sturgeon that allow shovelnose to successfully recruit at early life stages where the pallid sturgeon bottleneck is believed to occur.

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Table 7. Priorities for potential investigations

Priority	Investigation	Duration (years)	Anticipated Cost
1	Location of larval pallid sturgeon	4	$1,500,000
2	Develop reference conditions	1	$300,000
3	Fluid interactions around SWH	2-3	$250,000 - $750,000
4	Flows and availability of SWH	2	$300,000
5	Scale of SWH sites	5	$1,000,000
6	Drift distances of larval sturgeon	2	$300,000
7	Benefits of different types of SWH	1	$100,000
8	Distributions of SWH		
9	Growth rates & food of larval pallid sturgeon	3	$500,000
10	Amount of SWH w/out impacting navigation	2	$300,000
11	Amount of time for SWH development	3	$750,000
12	Revised quantitative definition	2	$250,000
13	Food resources for chub species	3	$375,000
14	Potential impacts of contaminants		
15	Potential impacts on invasive species	1	$100,000

Implementation and Decision-making

Strategy(s)

The SWH program, specifically the Habitat Assessment and Monitoring Program (HAMP), will take information gained from creation efforts and monitoring of physical and biological responses and analyze these data on an annual basis to help inform implementation and decision making. Due to the geographic scope of this program, AM principles will be applied at numerous scales including the overall amount of habitat to be restored, the distribution of restored habitat throughout the target segments, changes to design and creation techniques, and site-specific adjustments. Included below are example decision matrices that may be used to

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determine decision points in annual and periodic reviews to determine when modifications are warranted. Additional decision points are included in Appendix A related to the CEM.

Amount of Habitat to be Created

The BiOp calls for the creation of 12,035-19,565 acres of SWH to meet an overall goal of 20-30 acres per river mile (15,060-22,590 total acres). SWH creation also addresses the provisions of the BSNP Fish and Wildlife Mitigation Program which calls for 7,000-20,000 acres of habitat of this type. Inventories of the amount of SWH are complicated by two sets of criteria (the original definition and the qualitative clarified definition), multiple methods being used to delineate habitat, and an imprecise goal (20-30 acres per mile).

It remains uncertain how much of this habitat is needed in order to achieve the population objectives. Currently, about 3,443 acres have been restored with the potential of those projects to produce twice that amount in the future as habitat develops. There are approximately 9,400 acres of SWH currently present between Ponca, Nebraska and St. Louis, Missouri. As additional habitat is restored and uncertainties are clarified regarding the rate of habitat development, implementation plans (including the amount of habitat restored on an annual basis) may be altered in order to achieve acreage targets within the desired timeframes. Additionally, a combination of physical and biological responses will be used to determine whether sufficient habitat has been restored. As progress towards the SWH acreage target is made, assessments will be made to determine whether efforts should be focused on improving quality of the created habitat, whether additional habitat should be created, or whether all objectives have been met and efforts should focus on maintaining habitat quantity and quality.

There are three established check-in points for progress towards the SWH acreage goals:
2014 – Establish 30% of the target SWH acreage (3,611-5,780 acres)
2019 – Establish 60% of the target SWH acreage (7,221-11,739 acres)
2024 – Establish 100% of the target SWH acreage (12,035-19,565 acres)

In addition, annual and periodic (5-year) assessments will be made through the implementations process to determine if any adjustments to program implementation are warranted.

The following decision matrix relates SWH acreage and abundance of pallid sturgeon and other native fish. The matrix assumes that project-scale assessments have already indicated that habitat complexity is developing as expected and project scale biological metrics are responding. That is, hypotheses about the relationships between shallow water habitat complexity and larval fish are supported by monitoring data. Accordingly, “current SWH acres” are those that have achieved success at the project-scale, implying that project-scale biological and physical metrics are on track as well. In this matrix, dark green squares indicate the desired end states, light green squares indicate that progress is occurring, orange squares indicate situations where there may be a reversal in trends, red squares indicate situations where corrective adjustments may be warranted, and blue squares indicate situations in which fundamental hypotheses may be in question.

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Objective 2.1: Abundance of SWH	Objective 1: System Wide responses of pallid sturgeon and other native fishes	
	Abundance of pallid sturgeon and native fishes **steady or decreasing**	Abundance of pallid sturgeon and native fishes **increasing**
Current SWH acres **at or above target**	*Status:* Habitat developed but insufficient *Action:* Create more habitat, revise targets*	*Status:* Habitat developed and sufficient *Action:* Maintain if necessary
Current SWH acres **below target**, anticipated acres **at target**	*Status:* Habitat insufficient and developing *Action:* Wait and monitor	*Status:* Habitat developing, and already sufficient *Action:* Maintain if necessary, consider revising metrics or targets
Current and anticipated SWH acres **below target**	*Status:* Habitat insufficient *Action:* Create more habitat	*Status:* Habitat sufficient *Action:* Revise metrics or targets
SWH acres **decreasing**	*Status:* Habitat insufficient and declining *Action:* Create more habitat or improve existing habitat	*Status:* Habitat currently sufficient but declining *Action:* Monitor to determine need for habitat modifications

Figure W. Decision matrix for amount of SWH to be created

*This outcome could also indicate the hypothesized relationships between SWH and pallid sturgeon are at least partly incorrect, especially if some native fish populations are steady or increasing but pallid populations are not.

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Under this matrix, decisions as to whether to increase the amount of habitat would be based on both the amount of habitat currently in place that is meeting both physical and biological objectives and the trajectory of populations of pallid sturgeon and other native fish species. It should be noted that the amount of hatchery-raised pallid sturgeon must be taken into account when calculating the pallid sturgeon population growth rate to interpret these results.

Distribution of Restored Habitat

While the initial target for distributing SWH is to construct in target segments proportional to the size of each segment, investigations and analysis of collected data will be undertaken to determine whether there are biological benefits to other distributions of habitat or whether different types of SWH (backwaters, chutes, topwidth widening, etc.) have greater benefits in different locations. This information will be used to develop a long-term plan for distribution of different types of SWH within the target segments. This distribution will be tracked as part of the AM implementation phase and will be used to measure progress towards Objective 2. The current distribution of habitat is displayed in Table 8.

Table 8.- Estimated SWH Distribution as of 2009.

River segment	SWH Acres/mile
11 – Ponca to Sioux City	5.6
12 - Sioux City to Platte R.	5.6
13 - Platte R. to Kansas River*	9.4
14 - Kansas River to Osage R.	17.1
15 – Osage R. to mouth	18.4

An experimental approach and series of focused investigations should be used for project placement in order to increase understanding and adaptively manage project distribution.

Design and Construction Techniques

Data on physical habitat changes and biological responses will be used to help determine the effectiveness and potential benefits of various types of SWH (chutes, backwaters, structure modifications, etc.) as well as project features such as river tie-back channels, inlet structures, placement of LWD, and other features. This information will be used on an annual basis to influence design and construction techniques as well as alternative analysis at potential restoration sites.

Site Adjustments

Data from physical and biological responses at SWH creation sites will be used to determine whether or not site-specific adjustments are needed to achieve the desired habitat quality. Sites will be compared with best-achievable sites as described in the Monitoring and Assessment section. Progress towards biological and physical targets, as well as comparison amongst

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restored habitats, will be used to determine if a specific site requires additional work in order to achieve the stated objectives.

The following matrices reflect project-scale adjustments that may be warranted for both sites that are anticipated to develop and sites that are constructed to the desired condition. In these matrices, dark green squares indicate the desired end states, light green squares indicate that progress is occurring, orange squares indicate situations where there may be a reversal in trends, red squares indicate situations where corrective adjustments may be warranted, and blue squares indicate situations in which fundamental hypotheses may be in question.

Objective 3: Physical characteristics of SWH	Objective 4.1: Abundance of larval, YOY and juvenile native fish	
	Native larval fish absent or decreasing	Native larval fish abundant or increasing
Similar to best-achievable, at equilibrium	*Status:* Habitat developed but insufficient to support biotic community *Action:* Assess other potential limiting factors	*Status:* Habitat developed and sufficient *Action:* Maintain if necessary
Improving, becoming more-similar to best-achievable, **not at equilibrium**	*Status:* Habitat not yet sufficient but on development trajectory *Action:* Wait and continue to monitor	*Status:* Habitat developing, already sufficient *Action:* Monitor to ensure trends do not reverse
Stagnant, no significant increase or decrease, dissimilar to best-achievable, **not at**	*Status:* Habitat complexity insufficient and not developing *Action:* Modify habitat or wait for a significant flow event (if lacking)	*Status:* Habitat not developing, but sufficient *Action:* Consider revising metrics or targets

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	equilibrium		
	Physical habitat complexity decreasing	*Status:* Habitat insufficient and declining *Action:* Modify habitat or wait for a significant flow event if they have not occurred	*Status:* Habitat currently sufficient but declining in complexity *Action:* Monitor to determine need for habitat modifications

Figure X. Decision matrix for site-specific adjustments to SWH projects intended to develop over time

In the preceding matrix, trends in physical habitat complexity would be compared with trends in biological responses to determine whether or not a change is warranted at sites that are meant to develop through erosion and deposition processes and where biological responses are questionable. The next matrix relates to the construction of sites that are built to their desired final condition and where physical complexity is not anticipated to improve over time (namely backwaters). At these sites, there is little uncertainty regarding biological responses of phytoplankton, zooplankton, and benthic invertebrates. Monitoring is instead focused on physical aspects of the habitat and ensuring they have been constructed properly and are not degrading over time.

	Objective 3: Increase lateral connection of created habitat		
Objective 3: Emulate depth distributions of best-achievable		Lateral connectivity of habitat dissimilar from best-achievable habitat	Lateral connectivity of habitat similar to best-achievable habitat
	Depths similar to best-achievable habitat, no signs of significant sedimentation	*Status:* Habitat stable but constructed with insufficient lateral connectivity *Action:* Re-slope banks to establish lateral connectivity	*Status:* Habitat stable and constructed with adequate physical complexity *Action:* Maintain if necessary

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	Depths dissimilar from best-achievable habitat, no signs of significant sedimentation	*Status:* Habitat stable but constructed with insufficient physical complexity and lateral connectivity *Action:* Re-slope banks to establish lateral connectivity, consider dredging to improve depth distributions	*Status:* Habitat stable but constructed with insufficient physical complexity *Action:* Consider dredging to improve depth distributions
	Depths dissimilar from best-achievable habitat, signs of significant sedimentation	*Status:* Habitat actively filling in and constructed with insufficient physical complexity and lateral connectivity *Action:* Abandon habitat or re-slope banks to establish lateral connectivity, dredge to improve depth distributions and preserve connection to river	*Status:* Habitat actively filling in and constructed with insufficient physical complexity but with adequate lateral connectivity *Action:* Dredge to improve depth distributions and preserve connection to river

Figure Y. Decision matrix for site-specific adjustments to SWH projects constructed to desired end state

Adjustments to Objectives, Metrics, and Targets

During the implementation of the SWH AM Strategy, it may be necessary to adjust elements of the strategy to respond to new information garnered from ongoing monitoring and investigations. For example, the physical definition of SWH specifies average depths of less than 5 feet and average flows of less than 2 feet per second. However, some literature indicates that water velocities critical for survival of larval fish may be much lower - closer to 0.1 feet per second. If data collected through monitoring and investigations indicates that depth and velocity criteria, or other objectives, metrics and targets, need to be revised, they will be updated in the AM Strategy and may have implications for accounting methods, sampling designs or other aspects of the AM Strategy.

Implementation cycle

On an annual basis, data will be compiled and analyzed to assess progress towards the stated objectives and to report information gained from monitoring and investigations. This annual report will include recommendations related to all or some of the following decisions:

1. **Level of construction effort:** Continue with current, increase level of effort, or decrease level of effort. If a change to the level of effort is proposed, a cost estimate will be included along with a list of potential implications if the change is not adopted.
2. **Pilot projects:** Recommendations for new construction pilot projects, or new project features to be included, and associated costs and expected benefits. This will include

performance metrics, monitoring needs, and timeframe for monitoring to determine success.

3. **Site Adjustments:** Recommended actions to be taken at existing created SWH sites in order to improve these sites. Include methods, cost estimate, anticipated benefits and any additional monitoring necessary.
4. **Incorporation of new methodologies:** If previous pilot projects indicate that new methodologies will be successful, the team will recommend how these methodologies should be incorporated into the program and estimate changes in cost and expected benefits.
5. **Investigations:** Includes any new or additional investigations to be undertaken to address uncertainties associated with the program.

Every five years, additional analyses will be conducted in order to assess whether the elements of the SWH AM Strategy (including Objectives, Metrics, Targets, Monitoring, etc.) should be altered. If a decision is made to update the AM Strategy, a scope, schedule and plan of action will be developed to update the AM Strategy.

Responsible Parties

Three primary parties will be responsible for implementing this AM Strategy (including documentation). The SWH implementation PMs will be responsible for setting up and leading a series of calls and meetings that will occur between them, the SWH Product Delivery Team (PDT) and the MRRP AM Work Group (AMWG). The USACE, through the SWH PDT, will be responsible for gathering the data and conducting the primary data analyses. This group will also form recommendations for implementation of the SWH sub-program based on the results of the data. The AMWG will provide an outline of the annual review document, assist USACE in completing the annual report, and assist in facilitating the meetings, conducting analyses and documenting the annual review process. The AMWG will also assist in internal and external status updates and distribution of the annual and five-year AM reports.

Decision-making Process

Once the SWH AM Strategy is developed and finalized, the next step is to implement it. The SWH Implementation PM, in coordination with the SWH PDT, will develop a set of site specific management actions and monitoring and investigations needed associated with the SWH AM Strategy on an annual basis which will feed into the development of the MRRP Annual Work Plan. In addition to the primary management action of SWH creation, the Annual Work Plan may also include pilot projects to test new methodologies and adjustments to previously constructed projects.

The USACE Executive Steering Committee (ESC) will use the input from the Implementation PMs and the PDTs to establish MRRP priorities and create the MRRP Annual Work Plan. The Annual Work Plan includes real estate actions, habitat creation actions, monitoring of physical and biological responses to actions, and research activities. This Annual Work Plan is then used by PDTs to implement the management actions that make it into the final Annual Work Plan. As projects are constructed and operated, the Integrated Science Program (ISP) is responsible for monitoring the results of these management actions to track progress towards the objectives and metrics identified in the AM Strategy. In addition, the ISP conducts necessary investigations to reduce uncertainty associated with the management actions.

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The data from the monitoring efforts and investigations are provided to the PDTs and the AMWG for analysis and comparison to metrics from the AM Strategy. Following data analysis, the PDTs and the AMWG meet to discuss the results and any implications for the MRRP Annual Work Plan, including an assessment regarding whether the management actions are meeting the objectives or whether adjustments are needed in order to ensure success over time. The analysis and assessment, along with recommendations, are coordinated through the ISP and captured in an Annual AM Report. The Annual AM Report includes: 1) analysis of data collected; 2) evaluation of the effectiveness of actions towards achieving program objectives; 3) projected outcomes of actions using predictive models; 4) recommended Sub-Program or project adjustments; and 5) data needs and recommended research activities to improve predictive capabilities. As the Annual AM Reports are developed, independent review will be incorporated into the process as appropriate.

The draft report is then provided to the PDTs, CORE Team, the ESC, the appropriate MRRIC work group, the MRRIC, and other groups as appropriate. This provides an opportunity for these groups to gain an understanding of the MRRP at a key time in the annual cycle – occurring after information is compiled on the previous year's efforts, and before development of the next Annual Work Plan.

Feedback from these entities is provided to the PMs and PDTs through interaction with the AMWG and may result in changes to the multi-year action strategy or the development of the next Annual Work Plan. The cycle then repeats.

Periodically (every 5 years), the AM implementation phase will also involve a critical review of elements of the individual AM Strategies to see if adjustments to the AM Strategies are needed. If a recommendation is made to update an AM Strategy and major changes are warranted, the AM Strategy Development phase may be reinitiated in full or in part. This recommendation would come from the AMWG and the PDT and the decision to reinitiate the Strategy Development Phase would be made by either the CORE or the ESC, as appropriate. Otherwise, general updates would be made and coordinated through the external and internal teams described above under AM Strategy Development.

Additionally, MRRIC and other groups may choose to provide comments or recommended adjustments to AM Strategies at any time during the implementation phase. This could include changes to objectives, incorporation of additional management actions, input on anticipated benefits and tradeoffs, and other pertinent elements of AM Strategies. As these comments are received, they will be considered by the agencies, PDTs and AMWG and the AM Strategies will be updated as appropriate.

Reporting

The most recent SWH AM Strategy, annual AM reports, periodic (five-year) AM reports, reports on focused investigations, and other related reports will be made available to the public on www.moriverrecovery.org.

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Appendix A
Conceptual Ecological Model and List of Hypotheses

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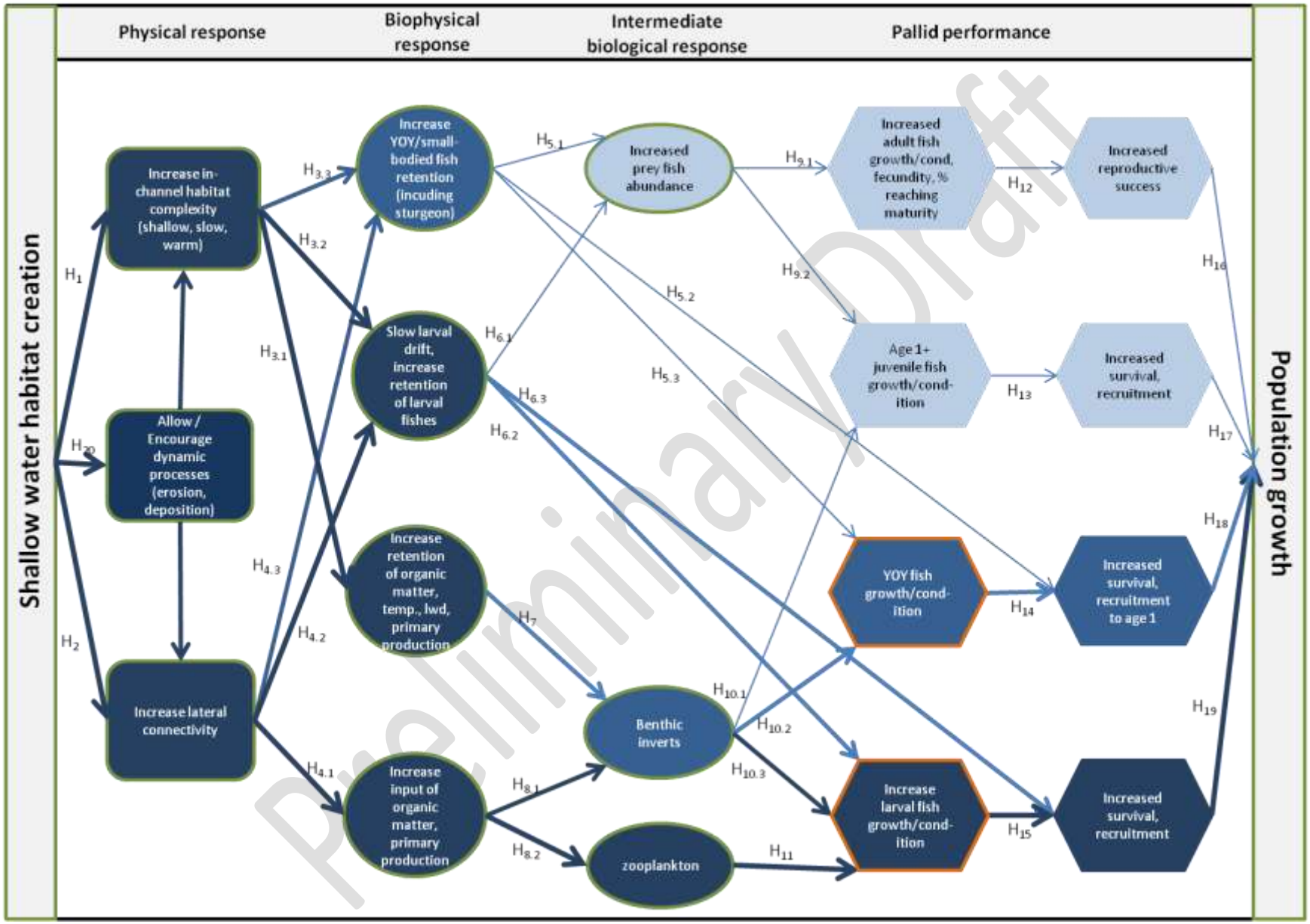

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SWH Conceptual Ecological Model Description

The above Conceptual Ecological Model (CEM) for SWH portrays the hypothesized linkages between the SWH management actions and the ultimate objectives related to pallid sturgeon. This CEM is organized by categories of responses:

Physical Response: Changes to physical characteristics of habitat (e.g. depth, velocity) arising from management actions and dynamic processes that alter those habitats following construction

Biophysical Response: Biological changes directly affected by the physical characteristics of habitat such as retention times

Intermediate Biological Response: Biological responses stemming from the Biophysical Responses and related to food sources for multiple life stages of pallid sturgeon

Pallid Performance: Indicators that relate biophysical responses and intermediate biological responses to pallid sturgeon life history, ultimately related to pallid sturgeon population growth

The CEM displays the likelihood of certain linkages being bottlenecks to population growth with heavier arrows and darker colored boxes. Boxes that are highlighted in green represent linkages that are proposed to be monitored in the SWH AM Strategy where boxes that are highlighted in orange represent linkages that are proposed to be addressed through focused investigations. Beside each arrow is an alphanumeric code relating to a hypothesis describing the connection between the two boxes which are described in the following section.

Hypotheses related to SWH Conceptual Ecological Model

The following list of hypotheses describes the relationships in the SWH Conceptual Ecological Model in a step-wise fashion and describes a framework for addressing successive hypotheses based on monitoring and investigations described in the SWH AM Strategy.

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H_{1a}: SWH projects increase channel/habitat complexity by increasing the prevalence of shallow, slow water, increasing the abundance of LWD, and increasing temperature variability by providing areas which warm more quickly during warm periods
H_{1b}: SWH projects do not increase channel/habitat complexity.
IF H1b THEN modify the SWH projects so they better create the desired channel/habitat complexity.

IF H1a THEN H3.1a, H3.2a, H3.3a:
$H_{3.1a}$: SWH projects increase organic matter retention due to increased habitat complexity including increased prevalence of shallow, slow water. Shallower, slower water also results in increased water temperatures and increased area where light penetrates to the bottom. As a result, primary productivity increases in these locations.
$H_{3.1b}$: SWH projects do not increase organic matter retention and primary productivity.
IF H3.1b THEN modify the SWH projects so they better retain organic matter. Evaluate whether density and/or size of projects is sufficient when uniformly distributed longitudinally to achieve desired increases in retention. Evaluate whether flow regime hinders habitats ability to retain organic matter.

IF H3.1a THEN:
H7a: Increased organic retention in SWHs results in increased abundance of benthic invertebrates at those locations.
H7b: Increased organic retention in SWHs does not result in increased abundance of benthic invertebrates at those locations.
IF H7b THEN determine what other factors may limit invertebrate abundance (e.g. water quality, predation, timing of flows, etc), evaluate whether density and/or size of projects is sufficient when uniformly distributed longitudinally to achieve desired benefits.
IF H7a: THEN:
H10.1a: Increased production of benthic invertebrates in SWH results in increased age 1+ fish growth/condition.
H10.1b: Increased production of benthic invertebrates in SWH does not result in increased age 1+ fish growth/condition.
IF H10.1b THEN conclude that invertebrate abundance is not limiting growth, investigate whether increased invertebrate abundance is occurring at the proper location and/or time
IF H10.1a: THEN
H13a: Increased growth/condition of age 1+ fish results in increased survival and recruitment to adult
H13b: Increased growth/condition of age 1+ fish does not result in increased survival and recruitment to adult
IF H13b THEN determine what other factors may be limiting recruitment to adult (e.g. predation)
IF H13a THEN:
H17a: Increased survival and recruitment to adult results in population growth
H17b: Increased survival and recruitment to adult does not result in population growth
IF H17b THEN determine what other factors may limit recruitment to adult (e.g. illegal harvest)
IF 17a THEN success, continue

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H3.2a: SWH slows drift and increases retention of larval pallid sturgeon and other native larval fishes
H3.2b: SWH does not slow drift or increase retention of larval pallid sturgeon and other native larval fishes
IF H3.2b THEN modify SWH projects to increase retention times and better retain larval pallid sturgeon and other larval fishes and/or modify projects to better permit access by drifting larval fishes. Consider related hypotheses, for example:

The distribution of SWH sites affects retention and dispersal of larval pallid sturgeon
Increased size or clustering of SWH projects results in enhanced biological response
SWH has greater benefits in areas downstream of spawning areas
An even distribution of SWH (20-30 acres/mile) will result in greater larval survival
Locating SWH near the mouths of major tributaries will increase benefits associated with the site.
Flows reduce ability of habitats to retain fish

IF H3.2a THEN H6.1, H6.2, H6.3
H6.1a: Increased retention of larval prey fishes results in increased abundance of juvenile and adult prey fishes
H6.1b: Increased retention of larval prey fishes does not result in increased abundance of juvenile and adult prey fishes
IF H6.1b THEN determine what other factors may limit abundance of prey fishes
IF H6.1a THEN H9.1, H9.2
H9.1a: Increased prey fish abundance results in increased growth/condition, fecundity, and/or % adults reaching sexual maturity
H9.1b: Increased prey fish abundance does not result in increased growth/condition, fecundity, and/or % adults reaching sexual maturity
IF H9.1b THEN conclude that prey fish abundance is not limiting for adult sturgeon, some data indicate condition may not be limiting for adults thus this pathway is not highlighted in the model
IF H9.1a THEN
H12a: Increased growth/condition, fecundity, and/or % adults reaching sexual maturity results in increased reproductive success
H12b: Increased growth/condition, fecundity, and/or % adults reaching sexual maturity does not result in increased reproductive success
IF H12b THEN determine what other factors may be limiting reproductive success
IF H12a THEN
H16a: Increased reproductive success results in population growth
H16b: Increased reproductive success does not result in population growth
IF H16b THEN determine what other factors may be limiting population growth
IF H16a THEN success, continue

H3.3a: SWH increases the retention of YOY pallid sturgeon and other native YOY and small-bodied fishes
H3.3b: SWH does not increase the retention of YOY pallid sturgeon and other native YOY and small-bodied fishes

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IF H3.3b THEN determine if modifications to SWH projects could better retain YOY fishes
IF H3.3a THEN H5.1, H5.2, H5.3
H5.1a: Increased retention of YOY and small-bodied native fishes (key prey species) results in increased abundance of those fishes
H5.1b: Increased retention of YOY and small-bodied native fishes (key prey species) does not result in increased abundance of those fishes
IF H5.1b THEN determine what other factors may limit abundance of key prey fishes
IF H5.1a THEN H9.1, H9.2
H9.1a: Goto…
H9.2a: Increased prey fish abundance results in increased growth/condition of juvenile (age 1+) pallid sturgeon.
H9.2b: Increased prey fish abundance does not result in increased growth/condition of juvenile (age 1+) pallid sturgeon.
IF H9.2b THEN conclude that abundance of these prey fishes is not limiting
IF H9.2a THEN
H13a: Increased growth/condition of age 1+ fish results in increased survival and recruitment to adult
H13b: Increased growth/condition of age 1+ fish does not result in increased survival and recruitment to adult
IF H13b THEN determine what other factors may be limiting recruitment to adult
IF H13a THEN:
H17a: Increased survival and recruitment to adult results in population growth
H17b: Increased survival and recruitment to adult does not result in population growth
IF H17b THEN determine what other factors may limit recruitment to adult (e.g. illegal harvest)
IF 17a THEN success, continue

H2a: SWH projects increase lateral connectivity
H2b: SWH projects do not increase lateral connectivity
IF H2b THEN modify projects so they better develop lateral connectivity
IF H2a THEN H4.1, H4.2, H4.3
H4.1a: Increased lateral connectivity results in areas of inundated vegetation, increased organic matter input, and in some cases areas of increased primary productivity
H4.1b: Increased lateral connectivity does not result in areas of inundated vegetation or increased organic matter input
IF 4.1b THEN evaluate the inundation timing, frequency, duration, and extent to determine what factors are preventing the desired seasonal inundation of vegetation
IF 4.1a THEN H8.1, H8.2
H8.1a: Seasonal inundation of terrestrial vegetation and increased input of organic matter increases abundance of benthic invertebrates.
H8.1b: Seasonal inundation of terrestrial vegetation and increased input of organic matter does not increase abundance of benthic invertebrates.
IF H8.1b THEN determine what other factors may limit abundance of benthic invertebrates (e.g. water quality)
IF H8.1a THEN H10.1, H10.2, H10.3
H10.1a: Go to H13

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H10.2a: Increased production of benthic invertebrates in SWH results in increased YOY fish growth/condition.
H10.2b: Increased production of benthic invertebrates in SWH does not result in increased YOY fish growth/condition.
IF H10.2b THEN conclude abundance of benthic invertebrates does not limit growth/condition of YOY fishes or increased abundance of invertebrates is not occurring in the proper locations
IF H10.2a THEN
H14a: Increased YOY fish growth/condition results in increased survival and recruitment to age 1
H14b: Increased YOY fish growth/condition does not result in increased survival and recruitment to age 1
If H14b THEN determine what other factors may limit survival and recruitment to age 1
IF H14a THEN H18
H18a: Increased survival and recruitment to age 1 results in population growth
H18b: Increased survival and recruitment to age 1 does not result in population growth
IF H18b THEN determine what other factors may be limiting population growth
IF H18a THEN success, continue

H10.3a: Increased production of benthic invertebrates in SWH results in increased larval fish growth/condition.
H10.3b: Increased production of benthic invertebrates in SWH does not result in increased larval fish growth/condition.
IF 10.3b THEN determine what other factors may limit larval condition, conclude benthic invertebrate abundance does not limit larval condition, other conditions prevent larval fish from benefitting from increased invertebrate abundance
IF 10.3a THEN
H15a: Increased growth/condition of larval fishes results in increased recruitment to post-larval stages
H15b: Increased growth/condition of larval fishes does not result in increased recruitment to post-larval stages
IF H15b THEN determine what other factors may limit recruitment to post-larval stages
IF H15a THEN
H19a: Increased larval survival and recruitment to post-larval stages results in population growth
H19b: Increased larval survival and recruitment to post-larval stages does not result in population growth
IF H19b THEN determine what other factors limit population growth
IF H19a THEN success, continue

H4.2a: SWH and associated laterally connected habitats slow drift and increase retention of larval pallid sturgeon and other native larval fishes
H4.2b: SWH and associated laterally connected habitats do not slow drift or increase retention of larval pallid sturgeon and other native larval fishes

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IF H4.2b THEN modify SWH projects so they more effectively increase retention times and slow larval drift, evaluate whether other factors such as flow regime are preventing these laterally connected habitats from functioning as desired
IF H4.2a THEN H6.1, H6.2
H6.1 go to H9.1, H9.2

H6.2a: Increased retention of larval fishes results in increased growth/condition
H6.2b: Increased retention of larval fishes does not result in increased growth/condition
IF 6.2b THEN evaluate whether other factors are limiting growth such as lack of proper food at the right time
IF 6.2a THEN H15 (go to H19)

H4.3a: SWH and associated laterally-connected habitats increase the retention of YOY pallid sturgeon and other native YOY and small-bodied fishes
H4.3b: SWH and associated laterally-connected habitats does not increase the retention of YOY pallid sturgeon and other native YOY and small-bodied fishes
IF H4.3b THEN modify SWH projects so they more effectively increase retention and increase habitat suitability for these small fishes, evaluate whether other factors such as flow regime are preventing these laterally connected habitats from functioning as desired
IF H4.3a THEN H5.1, H5.2, H5.3
H5.1a go to H9.1, H9.2
H5.2a: Increased retention of YOY sturgeon results in increased survival and recruitment to age 1
H5.2b: Increased retention of YOY sturgeon does not result in increased survival and recruitment to age 1
IF 5.2b THEN determine what other factors may be limiting recruitment to age 1
IF 5.2a THEN go to H18

H5.3a: Increased retention of YOY/small-bodied fishes results in increased growth/condition
H5.3b: Increased retention of YOY/small-bodied fishes does not result in increased growth/condition
IF H5.3b THEN determine what other factors may limit growth/condition
IF H5.3a THEN go to H14

H8.2a: Seasonally inundated habitats created by development of lateral connectivity produce increased abundance of zooplankton
H8.2b: Seasonally inundated habitats created by development of lateral connectivity do not produce increased abundance of zooplankton
IF H8.2b THEN modify SWH projects to increase retention times to promote increased zooplankton abundance, evaluate whether flow regime is preventing created habitats from producing desired benefits
IF H8.2a THEN
H11a: Increased zooplankton abundance results in increased growth/condition of larval fish
H11b: Increased zooplankton abundance does not result in increased growth/condition of larval fish

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increased zooplankton abundance coincides with larval fish presence
IF H11a THEN go to H15

H6.3a: Increased retention of larval fishes results in increased survival and recruitment to post-larval stages.
H6.3b: Increased retention of larval fishes does not result in increased survival and recruitment to post-larval stages.
IF H6.3b THEN evaluate other factors which may be limiting survival and recruitment of larval fish
IF H6.3a THEN go to H19

Pallid Sturgeon Hypotheses not related to SWH

There are also numerous other hypotheses related to pallid sturgeon that are not directly related to the abundance, distribution and quality of SWH that may help explain causal linkages between management actions and population responses. These hypotheses may need to be addressed through other investigations or monitoring efforts to completely understand the response of the pallid sturgeon population. (not listed in priority order)

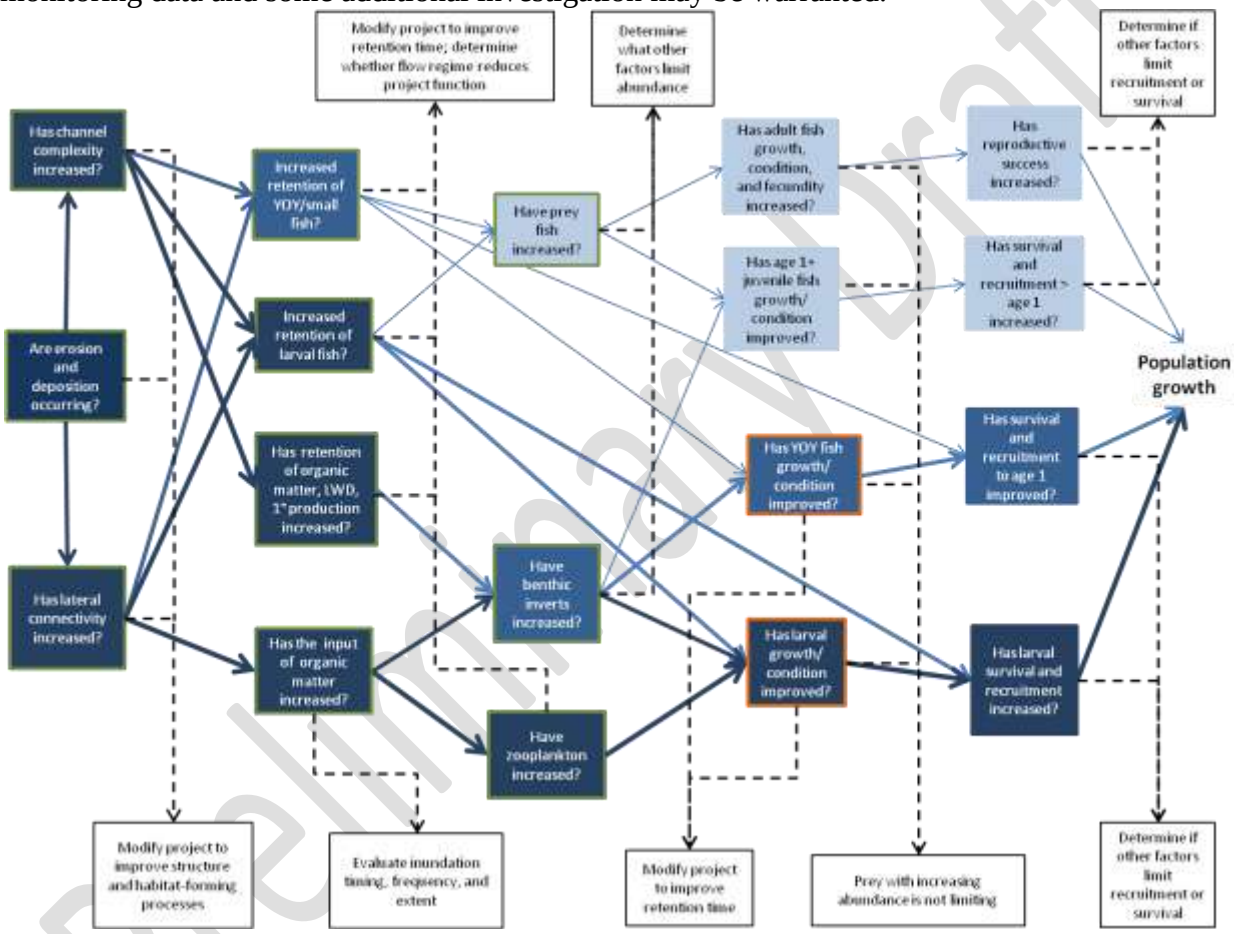
- Pallid sturgeon population growth is being limited due to hybridization between pallid sturgeon and shovelnose sturgeon.
- Higher than historic rates of predation are limiting pallid sturgeon population growth.
- Long drift distances are causing pallid sturgeon larvae to be carried from the Missouri River downstream to the Mississippi River.
- Habitat segmentation due to the placement of dams on the Missouri River has limited the potential migratory path length of pallid sturgeon.
- Water quality, particularly the presence of endocrine disrupters, is causing incidences of hermaphrodism and lowering rates of reproductive success.
- Declines in the overall pallid sturgeon population size have lead to a lack of an adequate number of reproductively-ready adults which has limited the potential for population growth.
- A lack of landscape-scale dynamic shifts in habitat has affected an important aspect of pallid sturgeon life history.
- Decreases in turbidity levels in the Missouri River have resulted in higher than historic rates of predation of larval and juvenile pallid sturgeon and/or decreased the ability of pallid sturgeon to compete for resources
- Introduction of predator species has increased rates of pallid sturgeon predation.
- A combination of reduced flow peaks and incised channel morphology has reduced floodplain connectivity which has lowered the productivity of the overall system during key rearing stages for larval and juvenile pallid sturgeon
- Changes in the channel morphology coupled with a lack of relatively low summer flows has decreased the availability of habitat for larval and juvenile pallid sturgeon.
- Introduction of non-native species (such as carp species) in the Missouri River has increased competition for food resources and negatively affected pallid sturgeon recruitment and/or growth rates.

Preliminary Draft

- Condition of reproductively-ready pallid sturgeon is reduced due to lack of resources, faster than historic channel velocities, or some combination of these and other factors.

Decision Tree Related to the SWH CEM

The following decision tree addresses potential decisions that may be made based on the results of monitoring to address hypotheses related to the SWH CEM. Solid lines indicate "Yes" responses or where hypotheses have been supported by monitoring data. Dashed lines represent "No" responses or where the desired response is not occurring and a corrective action is warranted. Dashed lines may also indicate where a hypothesis is not being supported by monitoring data and some additional investigation may be warranted.



Relationship of the SWH CEM to the draft Pallid Sturgeon Functional Model

As part of the development of the Missouri River Ecosystem Restoration Plan and Environmental Impact Statement, numerous functional models of the Missouri River ecosystem have been developed which are currently in draft form. One of these functional models relates to pallid sturgeon life history and the "Key Ecological Attributes" that affect it. This preliminary draft model is provided below to frame the SWH CEM in a broader context. Also included is draft text that describes the elements of the functional model and a graphic that depicts the relationship between elements of the SWH CEM and the pallid sturgeon functional model. The

following text is from the draft MRERP Focal Natural Resources Provisional Baseline Assessment Document and describes the pallid sturgeon functional model and its components: The purpose of this functional model is to describe the life cycle of pallid sturgeon by identifying life history states, transitions between these states, and their relation to KEA critical to the persistence of pallid sturgeon in the Missouri River ecosystem (Figure D-15). This model is based on the pallid sturgeon life history model developed by Wildhaber et al. (2007) and modified to emphasize relationships between the various states, transitions, and KEAs. The following KEAs are important to some but not all states or transitions within the Pallid Sturgeon FNR.

River Flows

This "master variable" KEA has a major effect on a large number of KEAs. River flows are responsible for moving sediment (NRC 2002), and so this KEA is related to River Sediment. The flows also affect River Water Chemistry and River Water Temperature by affecting the chemical and thermal dynamics of the river (Junk et al. 1989; Hesse et al. 1989; Hesse and Sheets 1993). River flows drive connectivity (Tockner and Stanford 2002) and affect habitat generation (Bayley 1995), so this KEA is linked to River–Floodplain Connectivity and River–Floodplain Habitat Turnover. River flows affect biota, as they are responsible for moving organic matter and nutrients vital to the persistence of living creatures in the river system (River Food Web; Junk et al. 1989); they affect Native River and Floodplain Vegetation (Johnson 1992); and play a role in the life cycles of various creatures living in the river channel (Native River Wildlife; Hesse et al. 1993).

River Water Temperature

This KEA is affected by River Flows. The continuous movement of water, and the seasonal and extreme flows, bring in warm or cold waters and/or aid in the formation of ice cover. The volume of water is directly related to its thermal inertia. This KEA affects River Flows, River Water Chemistry, River–Floodplain Habitat Turnover, River Food Web, Native River Wildlife, and Native River and Floodplain Vegetation. River water temperature, in conjunction with river flows, affects the growth and development rates of numerous organisms (Diana 1995; McCullough 1999), and triggers life history events such as spawning and hatching (Lehmkuhl 1972; Galat et al. 1996; Phelps et al. 2010). Water temperature influences dissolved oxygen concentration in the water, and strongly affects the physiologic state of numerous aquatic organisms. Extreme temperatures and extremely low dissolved oxygen levels can kill organisms (Sargent and Galat 2002; SDDENR 2008) or trigger transitions to dormant states. Temperature influences the River Food Web at all trophic levels. Water temperature affects primary production due to the temperature optima of phytoplankton, periphyton, and macrophytes. The rate of primary production influences the amount of oxygen produced by photosynthesis and the amount in the water. This also influences the higher trophic levels of the River Food Web, because temperature can affect the capture efficiency of predators (Herzog 2004; Wuellner et al. 2010). Temperature changes affect not only Native River Wildlife and Native River and Floodplain Vegetation, but also the River Food Web due to the interrelationship between fauna and flora. The river temperature and hydrologic regimes jointly determine the dynamics of ice formation, breakup, and transport, which influences geomorphology and habitat in the river and on the floodplain.

Preliminary Draft

River Water Chemistry

This KEA affects the River Food Web, Native River Wildlife, and Native River and Floodplain Vegetation KEAs. If a system is nutrient-limited, increases or decreases in nutrient availability can shift primary productivity, thereby altering the base of the food web (Chapman et al. 2003). Fish and benthic macroinvertebrates can be indirectly affected by nutrients through effects on algal food resources and the resulting hypoxic or anoxic conditions (Sargent and Galat 2002), and studies have shown that some forms of nitrogen (ammonia and nitrite) have toxic effects on juvenile mussels (Myers-Kinzie 1998) and fish (Randall and Tsui 2002). Water pH levels affect the availability and uptake of metals, nutrients, and carbon dioxide in water and sediment, having an effect on various aquatic organisms. High levels of turbidity limit light penetration and can interrupt primary productivity in the forms of phytoplankton and submergent macrophytes in the river and within wetlands. The bioaccumulation of contaminants and metals in aquatic fauna has an impact on organismal health, at all levels of the food chain, from zooplankton to macroinvertebrates to fishes to fish predators (Lemly 1993; Schmitt 2004). The sensitivity of aquatic fauna and flora to levels and forms of nutrients, pH, dissolved oxygen, turbidity, and pollutants in the sediment and water could alter the diversity, abundance, growth, and/or productivity of these species, and lead to mortality of sensitive species and/or increased diversity and abundance of tolerant and nonnative species (Mauk and Brown 2001). This affects not only Native River Wildlife and Native River and Floodplain Vegetation, but also the River Food Web, due to the interrelationship between fauna and flora.

Native River Wildlife

The health and composition of the fish and macroinvertebrate assemblages could affect the food web of the river as well as the native floodplain wildlife. These fauna are links within the food web; they are consumers of energy as well as food resources for higher trophic levels. If the species diversity or richness of the native assemblages is altered, then the various interrelationships in the food web could experience unnatural shifts, disruptions, or disconnections. In addition, many fauna play a role in the decomposition of matter crucial to the stability of the food web (Delong et al. 2001; Thorp et al. 2006).

This KEA is affected by River Flows, River Water Chemistry, River Water Temperature, River Food Web, Native Floodplain Wildlife, River–Floodplain Connectivity, and River Habitat Connectivity. Dynamic and seasonal river flows and river–floodplain connectivity allow for crucial exchange of nutrients, biota, and energy up and down the main channel as well as between the river and floodplain (Bayley 1995). This connectivity aids in the reproduction, growth, and movement of native river wildlife (Delong et al. 2001). The River Food Web connects Native River Wildlife and Native Floodplain Wildlife. Variations in River Water Chemistry and River Water Temperature provide dynamic conditions throughout the riverine habitats and how native river wildlife respond depends on their individual sensitivities or tolerance to particular conditions.

River-Floodplain Habitat Turnover

River Flows and River Sediment are the driving forces behind this KEA (Junk et al. 1989; NRC 2002; Sluis and Tandarich 2004). River flows move and redeposit sediment to generate new habitat (River Habitat Quality and Floodplain Habitat Quality). River–Floodplain Connectivity also interrelates with this KEA, as connectivity between the river and its floodplain facilitates habitat turnover (Bayley 1995; NRC 2002; Whitledge et al. 2005).

Pallid Organismal Condition

Pallid Sturgeon Organismal Condition has interrelationships with River Habitat Quality and River Food Web, which support the animals upon which pallid sturgeon prey (Gerrity et al. 2006; Wanner et al. 2007) and the physical environment in which they live.

Pallid Growth

As with Pallid Sturgeon Organismal Condition, Pallid Sturgeon Growth has interrelationships with River Habitat Quality and River Food Web, which support the animals that pallid sturgeon require for food (Gerrity et al. 2006; Wanner et al. 2007) and the physical environment in which they live. Without food and suitable foraging habitat, the development of new tissues is impossible, and growth stops.

Pallid Early Juvenile Food Availability

This KEA has interrelationships with Pallid Sturgeon Organismal Condition and Pallid Sturgeon Growth where these KEAs apply to pallid sturgeon in the early juvenile life stage. The availability of suitable food for early juvenile pallid sturgeon supports their growth and condition. This KEA also has interrelationships with River Habitat Quality, River Food Web, and Native River Wildlife, all important ecological components that produce the organisms upon which early juvenile pallid sturgeon feed.

River Sediment

River sediment is responsible for turbidity in the river system (Blevins 2006), linking this KEA to River Water Chemistry. As a building material contributing to river and floodplain macrohabitat complexity (NRC 2002; Sluis and Tandarich 2004), this KEA has a strong link to River–Floodplain Habitat Turnover, River Habitat Quality, and Floodplain Habitat Quality. Also, river sediment plays a role in the life cycle of various organisms living in the river, and so this KEA is linked to the River Food Web and to Native River Wildlife.

River Habitat Quality

River–Floodplain Habitat Turnover, in combination with River Flows and River Sediment, creates and maintains a diversity of channel forms (Funk and Robinson 1974; Junk et al. 1989; NRC 2002). River Habitat Quality, in turn, affects River–Floodplain Habitat Turnover by directing and absorbing the energy with which floodwaters move along different paths from the channel to the floodplain. Interrelationships also exist among this KEA and the biotic KEAs River Food Web, Native River Wildlife, Native Floodplain Wildlife, and Native River and Floodplain Vegetation), because the type, availability, and quality of river habitats determine whether organisms can successfully feed, reproduce and raise young. Floodplain Habitat Size and Connectivity interrelates with this KEA as well, due to the import of large wood from the floodplain during high-flow events and their effects on habitat.

River Habitat Connectivity

This KEA affects River Sediment because sediment can move longitudinally through the river channel only to the degree at which there is longitudinal connectivity. This KEA also affects the biotic KEAs (River Food Web, Native River Wildlife, Native Floodplain Wildlife, and Native River and Floodplain Vegetation) to the degree to which the particular organisms concerned require longitudinal connectivity for successful completion of their life cycles, or to make them available as prey for other organisms.

Preliminary Draft

Pallid Reproductive Success

Pallid Sturgeon Reproductive Success has interrelationships with River Flows and River Water Temperature, both of which are factors in determining the suitability of the river environment for larval fish survival. It also interrelates with River Habitat Size and Connectivity, which affects the ability of the pallid sturgeon to migrate upstream to mate, and the ability of the larva to drift downstream after hatching (Braaten et al. 2008).

Pallid Population Size

Pallid Sturgeon Population Size interrelates with River Habitat Quality. This KEA supports the particular type of physical environment necessary to support the existence of a stable population of pallid sturgeon.

The model depicts the pallid sturgeon life cycle using seven distinct life states. States are represented as boxes with black bold borders in the conceptual model. Arrows show the sequential progression of one state to the next in the life cycle, representing transitions between states. Transitions appear as ovals. States and transitions are numbered sequentially (Table D-10 and Figure D-15). The spatial element of the model is depicted by a river graphic and states and transitions are arranged around the river to illustrate the spatial movement of life stages either upstream (migration) or downstream (drift). Arrows are color coordinated to depict when these movements are taking place in the state/transition cycle. Black boxes represent KEAs, as determined through coordination with the aquatic technical team.

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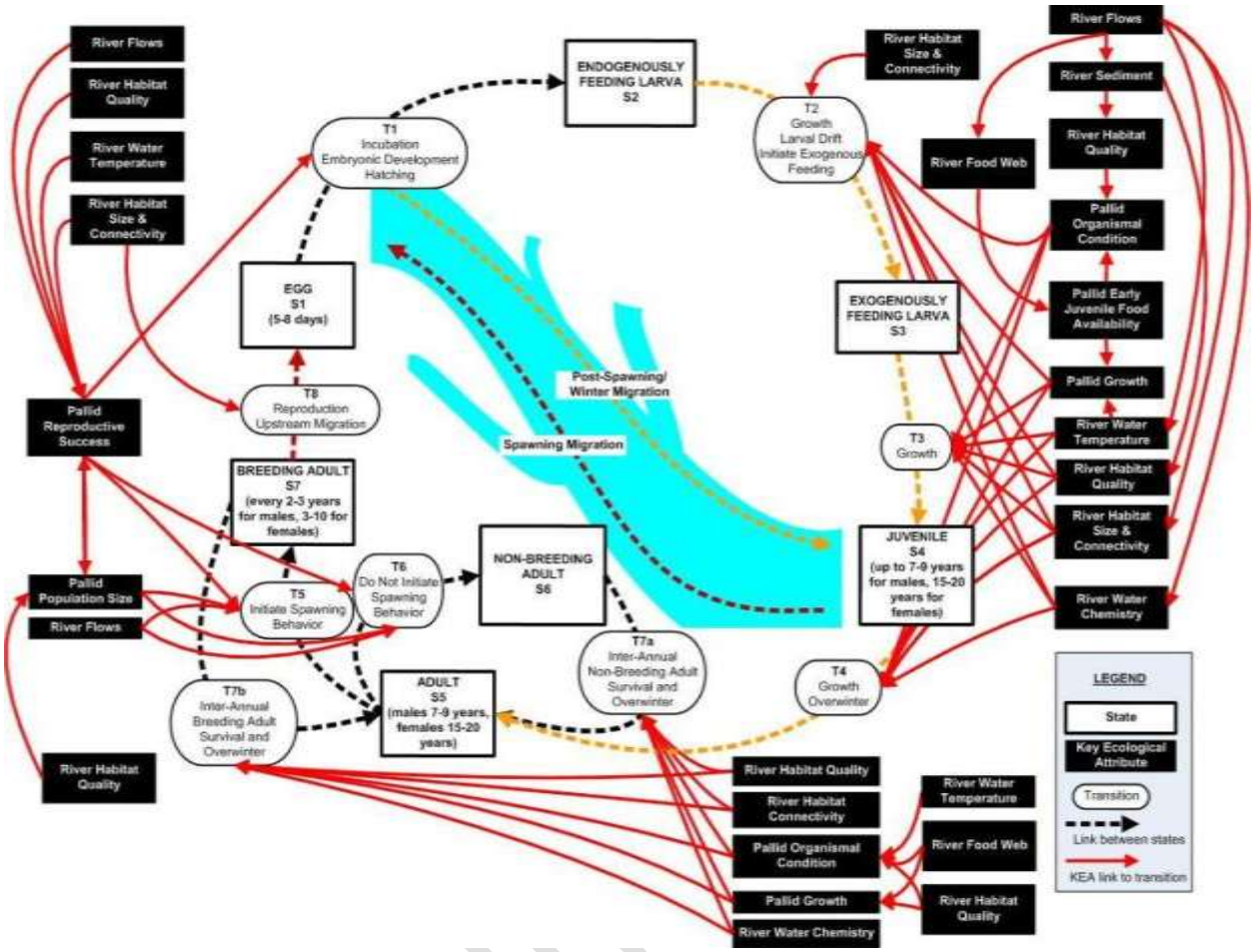

TABLE D-10: PALLID STURGEON STATES AND TRANSITIONS (LIFE HISTORY)

Description
S1. Egg **T1. Incubation/Embryo Development/Hatching**
The egg is the initial life state of the pallid sturgeon. The egg becomes adhesive soon after release and attaches to the substrate until hatch. Pallid sturgeon eggs are spawned over coarse substrate in or adjacent to the main river channel. Once deposited, the egg incubates and the embryo develops until it hatches, typically within 5-8 days. It is important that eggs are not covered by silt during this time, as this may prevent them from receiving oxygen. Egg oxygen requirements generally increase with development, being greatest at hatch (Wildhaber et al. 2007).
S2. Endogenously Feeding Larva **T2. Larval Drift/Initiate Exogenous Feeding**
After hatching, larvae obtain energy from their own internal yolk sac (endogenous feeding). The transition between endogenously and exogenously feeding larvae is the initiation of ingestion of external foods (T2). Drift is the passive dispersal of the larvae carried by the flow of river water from the site of hatching to comparatively more stationary rearing habitats. Laboratory studies have shown larval pallid sturgeon drifting freely for up to 13 days (Kynard et al. 2002). Once larval pallid sturgeon stop drifting and consume the entire reserve of their internal yolk sac, they begin feeding on other organisms (Braaten et al. 2008).
S3. Exogenously Feeding Larva **T3. Growth**
Exogenous larvae have fully digested their own yolk sac and must begin feeding on other organisms. Food habits of exogenous larval pallid sturgeon are poorly understood (Wanner et al. 2007; Grohs et al. 2009);

Description
however, they likely feed on small invertebrates and plankton at this life cycle state (Wanner et al. 2007; Wildhaber et al. 2007; Grohs et al. 2009). They begin to occupy benthic habitats to feed (Wildhaber et al. 2007). Habitats occupied appear to be adjacent to (or readily accessible from) the thalweg (i.e., source of drifting sturgeon) with relatively fast velocity (0.5-0.7 m/s) over sand dominated substrate and in moderate depth (1.7-3.0 m) (Ridenour et al. In Press). The transition from Exogenous Larvae (S3) to a Juvenile (S4) is generally characterized by continued growth as a result of a net gain between energy intake and energy output. The transition from Exogenous Larvae (S3) to a Juvenile (S4) is generally characterized by continued growth as a result of feeding net gain between energy intake and energy output.
S4. Juvenile **T4. Growth/Overwinter**
Juvenile pallid sturgeon have matured enough to be able to consume larger prey items such as fishes, but are not yet sexually mature. Fish prey, especially chubs, constitute an important part of the pallid sturgeon's diet at this state (Gerrity et al. 2006), although they also feed on macroinvertebrates (Grohs et al. 2009). They must be able to seek refuge as necessary from drought, floods, and high temperature. The transition from juvenile to adult pallid sturgeon is generally characterized by continued growth and over-wintering survival.
S5. Adult **T5. Initiate Spawning Behavior** **T6. Do not initiate spawning behavior**
The Adult state (S5) refers to pallid sturgeon that are fully sexually mature and capable of breeding. Male pallid sturgeon are sexually mature at 7-9 years of age, and females at 15-20 years of age (Keenlyne and Jenkins 1993). Breeding occurs every 2-3 years for males and every 3-10 years for females (Keenlyne and Jenkins 1993). Food habits and refuge needs are similar to those of the Juvenile state (S4), yet adults consume larger prey items. Initiation of spawning behavior (T5) is characterized by hormonal changes, gonad maturation, and pre-spawning movements (migration), while spawning behavior itself is characterized by aggregation, courtship, and reproduction. Photoperiodic and hydrologic cues likely play a role in initiating spawning behaviors (Bramblett 1996). Available evidence suggests that pallid sturgeon spawn in the spring or early summer, and release their eggs at intervals (USFWS 2000). An adult pallid sturgeon in a nonbreeding year would not initiate spawning behavior (T6).
S6. Nonbreeding Adult **T7a. Interannual nonbreeding adult survival and overwinter**
The Interannual Nonbreeding Adult Survival transition (T7a) is linked in a circular fashion to the Adult state (S5), showing that nonbreeding adults must survive the nonbreeding years in order to be capable of breeding successfully (potentially transitioning to the Breeding Adult [S7] state) the next year or future years.
S7. Breeding Adult **T7b. Interannual breeding adult survival and overwinter** **T8. Reproduction/Spawning migration (upstream)**
Reproductive pallid sturgeon engage in spring spawning runs that may traverse many miles, necessitating unimpeded longitudinal connectivity (Bramblett 1996; Bramblett and White 2001; DeLonay and Little 2002; Sheehan et al. 2002). Populations of breeding adults must be of a size sufficient to facilitate encounters between individuals and initiation of successful spawning behavior. Successful spawning results in fertilized eggs being deposited over gravel/cobble substrate (S1). Breeding adults (S7) return to the Adult state (S5), after breeding successfully, if they overwinter and survive through the following year (T7b). They will then be Nonbreeding Adults (S6) until they are able to breed again.

The following table shows the relationship between KEAs in the pallid sturgeon functional model and components of the SWH CEM.

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Pallid Sturgeon Functional Model Key Ecological Attribute	Shallow Water Habitat Conceptual Ecological Model Component	Relationship
River Habitat Size and Connectivity	Shallow Water Habitat Creation	Both address the quantity of habitat in the river
River-Floodplain Connectivity	Increase lateral connectivity	Lateral connectivity addresses a subset of overall river-floodplain connectivity
River Habitat Quality	Increase in-channel habitat complexity	Both address channel form, depth diversity, habitat diversity, and abundance of LWD
River-Floodplain Habitat Turnover	Allow / encourage dynamic processes	Both address the amount of habitat re-worked by dynamic processes
River Food Web	Increase retention of organic matter, temp, primary production	The four CEM components address various indicators of the River Food Web KEA including phyotplankton and periphyton, chlorophyll-a, cyprinids, zooplankton, particulate organic matter, and fish length and biomass.
	Increase input of organic matter, primary production	
	Increased prey fish abundance	
	Zooplankton	
Pallid Early Juvenile Food Availability	Benthic inverts	Both address the abundance of benthic macroinvertebrates
Pallid Growth	Increased adult growth/condition	The two pallid KEAs and the four CEM components all address the growth and condition of multiple life stages of pallid sturgeon
Pallid Organismal Condition	Age 1+ juvenile growth/condition	
	YOY fish growth/condition	
	Larval fish growth/condition	
Pallid Sturgeon Reproductive Success	Increased reproductive success	Both address the reproductive success, survival, and recruitment of multiple life stages
	Increased survival, recruitment	
Pallid Population Size	Population growth	Both address the size and trends of the population

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Appendix B: Project Delivery Team Members

Role	Role / Uncertainty to be addressed	Area of Expertise Required	PDT Members
Team Lead	Ensure information improves design and is implementable	River Engineering	Zach White (USACE)
AM Process Managers	How the AM process will integrate with USACE guidelines and the MRRP	USACE AM Guidelines, USFWS AM Guidelines, ESA	Tim Fleeger (USACE) / Carol Hale (USFWS)
Quantity of SWH	Amount of SWH needed to support pallid sturgeon; amount of existing SWH; impacts to authorized purposes; aquatic habitat monitoring & design priorities	Fish Biology, USACE authorized purposes, flood control features, surveys, hydrology	Joe Bonneau (USACE) / Mike Chapman (USACE) / Dan Pridal (USACE)
Quality of Created SWH	Timeline for development of created habitats, relative benefits of SWH - river control structure modifications, side channels, backwaters, tie-back channels, inlet/outlet structures, chute designs, etc.	Fluvial Geomorphology, SWH design, statistics, Fish Biology	Robb Jacobson (USGS) / Chris Larson (IDNR) / Wyatt Doyle (USFWS) / Vince Travnichek (MDC)
Quality of Created SWH	Effects of habitat creation on metrics identified in SWH definition (primary and secondary productivity, temperature, fish community composition, habitat diversity, etc.).	Aquatic Ecology, invertebrates, fish biology	Mark Boone (MDC) / Schuyler Sampson (NGPC)
Quality of Created SWH	Water quality associated with SWH	Water Quality	Larry Shepard (EPA)
Distribution of Created SWH	Proximity to other features (major tributaries, wetland complexes), lustered vs. evenly-spaced, etc.	Mitigation habitat, natural resource management	Wedge Watkins (USFWS)
Distribution of Created SWH	Upstream vs. downstream, effect on drift distances; usage during different life stages	Pallid sturgeon life history, ecological models	Rob Klumb (USFWS) / Aaron DeLonay (USGS),

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Appendix C: Clarified Definition of Shallow Water Habitat