MISSOURI RIVER
RECOVERY PROGRAM

FINAL

Missouri River Recovery Management Plan and Environmental Impact Statement

VOLUME 1

August 2018

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MISSOURI RIVER RECOVERY MANAGEMENT PLAN AND ENVIRONMENTAL IMPACT STATEMENT

Tiffany Vanosdall, Project Manager
United States Army Corps of Engineers, Omaha District
1616 Capitol Avenue
Omaha, Nebraska 68102
email: cenwo-planning@usace.army.mil.

Abstract

On August 31, 2018, the United States Army Corps of Engineers (USACE) issued a Notice of Availability of the Final Missouri River Recovery Management Plan and Environmental Impact Statement (MRRMP-EIS), and filed it with the U.S. Environmental Protection Agency. The Draft MRRMP-EIS was released on December 23, 2016 and included a 122-day public comment period that ended on April 24, 2017. During that time USACE held six public meetings to solicit comments from the public. USACE analyzed the comments received from the public and considered them in preparation of the Final MRRMP-EIS (Appendix K: Tribal, Public, and other Agency Comments and Responses on the Draft EIS). This Final MRRMP-EIS is available for public review until October 9, 2018.

The MRRMP-EIS is a joint effort between the Omaha and Kansas City Districts of USACE, in cooperation with the U.S. Fish and Wildlife Service (USFWS). The purpose of the MRRMP-EIS is to develop a suite of actions that meets Endangered Species Act responsibilities for the interior least tern, Northern Great Plains piping plover, and pallid sturgeon. Authorities used to meet this purpose may include existing USACE authorities related to Missouri River System operations for listed species and acquisition and development of land needed for creation of habitat for listed species provided by Section 601(a) of the Water Resources Development Act (WRDA) 1986, as modified by Section 334(a) of WRDA 1999, and further modified by Section 3176 of WRDA 2007, although alternatives formulation was not limited to these authorities.

The document is divided into six primary chapters. “Chapter 1: Purpose and Need” describes why USACE is taking action at this time and what USACE intends to achieve. “Chapter 2: Alternatives” presents the approach to developing and screening alternatives and six alternatives examined in-detail—five action alternatives and the No Action alternative. The alternatives evaluated provide different approaches to addressing the need for the EIS and meeting species objectives. “Chapter 3: Affected Environment and Environmental Consequences” describes the existing conditions of 22 resource topics including physical, natural, and human consideration resources and the projected impacts to those resources from the six alternatives evaluated. “Chapter 4: Implementation of Preferred Alternative under the Science and Adaptive Management Plan” describes how adaptive management would be used to adjust the initial suite of actions over time based on new understanding of biological responses. The accompanying Science and Adaptive Management Plan details the full adaptive management plan for the MRRP. “Chapter 5: Tribal, Agency, and Public Involvement” describes the public involvement process and the Tribal and state consultation processes that contributed to the development of the MRRMP-EIS. Finally, “Chapter 6: Compliance with Other Environmental Laws” describes how the USACE has complied with or will comply with other laws prior to implementing any decision.

The six alternatives considered in this MRRMP-EIS include the following: Alternative 1—No Action alternative, as required by the National Environmental Policy Act and based on the current System operation and current implementation of the Missouri River Recovery Program; Alternative 2—USFWS 2003 Biological Opinion Projected Actions; Alternative 3—Mechanical Construction Only; Alternative 4—Spring Emergent Sandbar Habitat (ESH) Creating Release; Alternative 5—Fall ESH Habitat Creating Release; and Alternative 6—Pallid Sturgeon Spawning Cue.

The MRRMP-EIS evaluates the direct, indirect, and cumulative impacts of the six alternatives. Based on these projected impacts, the ability to meet the plan’s purpose, need, and species objectives, and other decision criteria, USACE has identified Alternative 3—Mechanical Construction Only as its preferred alternative. Importantly, Alternative 3 would be implemented under the science and adaptive management framework summarized in Chapter 4 of the MRRMP-EIS and detailed within the Science and Adaptive Management Plan.

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Missouri River Recovery Management Plan and Environmental Impact Statement

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Executive Summary

Introduction

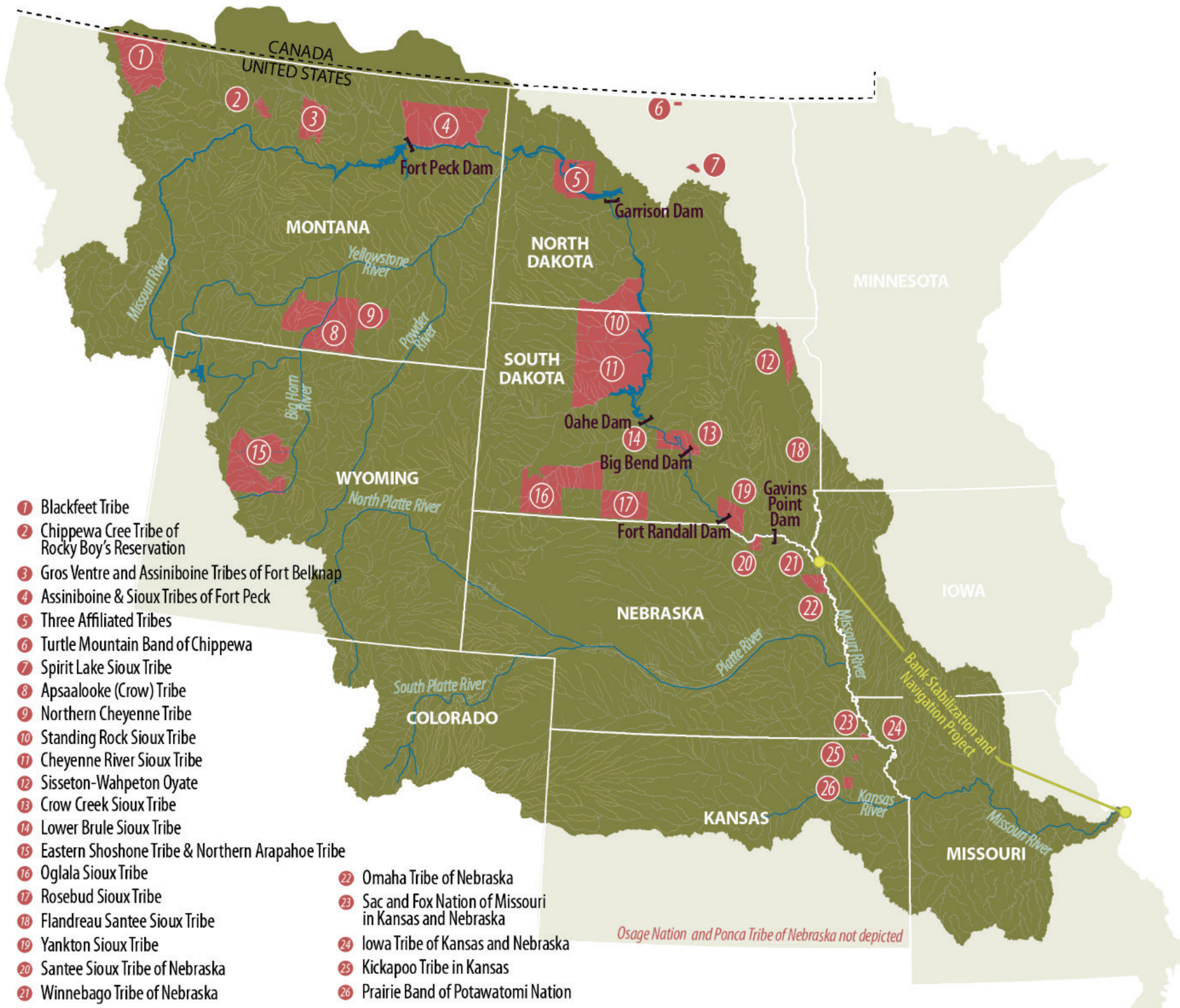
The Kansas City and Omaha Districts of the U.S. Army Corps of Engineers (USACE), in cooperation with the U.S. Fish and Wildlife Service (USFWS), have developed the Missouri River Recovery Management Plan and Environmental Impact Statement (MRRMP-EIS or Management Plan). This document is a programmatic assessment of major federal actions necessary to avoid a finding of jeopardy to the pallid sturgeon (*Scaphirhynchus albus*), interior least tern (*Sterna antillarum athalassos*), and the Northern Great Plains piping plover (*Charadrius melodus*) caused by operation of the Missouri River Mainstem and Kansas River Reservoir System and operation and maintenance of the Missouri River Bank Stabilization and Navigation Project (BSNP) in accordance with the Endangered Species Act (ESA) of 1973, as amended. This programmatic document also assesses the Missouri River BSNP fish and wildlife mitigation plan described in the 2003 Record of Decision (ROD) and authorized by the Water Resources Development Act (WRDA) of 1986, 1999, and 2007 as it relates to endangered species.

Background

The Missouri River flows for 2,341 miles from Three Forks, Montana at the confluence of the Gallatin, Madison, and Jefferson Rivers in the Rocky Mountains through the states of Montana, North Dakota, South Dakota, Nebraska, Iowa, Kansas, and Missouri. It is the longest river in the United States. USACE operates six dams and reservoirs with a capacity to store 72.4 million acre-feet (MAF) of water, the largest reservoir system in North America. USACE operates the Missouri River Reservoir System (System) to serve eight congressionally authorized project purposes of flood control, navigation, irrigation, hydropower, water supply, water quality, recreation, and fish and wildlife. Runoff from the upper Missouri River Basin is stored in reservoirs behind the Mainstem dams: Fort Peck, Garrison, Oahe, Big Bend, Fort Randall, and Gavins Point. Released water from the lowest dam in the System, Gavins Point Dam, flows down the Lower River from Sioux City, Iowa to St. Louis, Missouri (shown in the figure below). USACE operates the System in accordance with the policies and procedures prescribed in the *Missouri River Mainstem Reservoir System Master Water Control Manual* (Master Manual).

USACE also constructed and maintains the Missouri River BSNP. The BSNP consists mainly of rock structures and revetments along the outsides of bends and dikes along the insides of bends to force the river into a channel alignment that is self-maintaining.

In order to maintain System benefits, the construction, operation, and maintenance of the System and the BSNP have resulted in hydrologic alterations to the Missouri River ecosystem including changes to the natural seasonal pattern of river flow and sediment transport. Alteration and loss of aquatic and terrestrial habitat have also occurred.



Missouri River Mainstem Reservoir System

The pallid sturgeon, interior least tern, and Northern Great Plains piping plover are found in and along the Missouri River. The pallid sturgeon is a large, long-lived benthic (i.e., bottom-dwelling) fish that inhabits the turbid, fast-flowing rivers of the Missouri and Mississippi River basins. The interior least tern and piping plover are migratory birds that occur on the Missouri River during the breeding season and nest on emergent sandbar habitat (ESH). Declines in the populations of these species led to the USFWS listing of the interior least tern as endangered in 1985, the Northern Great Plains piping plover as threatened in 1985, and the pallid sturgeon as endangered in 1990 under the ESA.

> ***Jeopardy****: Occurs when an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species.*
>
> ***Recovery****: An improvement in the status of listed species to the point at which listing is no longer appropriate under the ESA.*

USACE has a responsibility under the ESA to take actions to ensure that the operation of the Missouri River System and operation and maintenance of the BSNP are not likely to jeopardize the continued existence of threatened and endangered species or adversely modify critical habitat.

Beginning in 1987, the USFWS and USACE engaged in consultation in compliance with Section 7 of the ESA, concerning impact of current reservoir operations on the listed birds which resulted in a 1990 Biological Opinion (BiOp) with a finding of jeopardy. These consultations continued after the pallid sturgeon was listed and later included proposed reservoir operations under the revised Master Manual and the operation and maintenance of the BSNP. In the 2000 BiOp, USFWS concluded that operating the System, operating and maintaining the BSNP, and operating the Kansas River Reservoir System, as proposed, would jeopardize the continued existence of the federally listed pallid sturgeon, interior least tern, and piping plover. The BiOp, which applies to the portion of the Missouri River from Fort Peck, Montana, to St. Louis, Missouri, identified a Reasonable and Prudent Alternative (RPA) to avoid a finding of jeopardy consisting of several actions to be taken by USACE. In 2003, USACE reinitiated formal consultation with USFWS and provided a Biological Assessment (BA) with new proposed actions in November 2003. The 2003 BA was provided because of new information concerning the effects of USACE actions that had previously not been considered and because USACE believed certain components of the RPA did not comport with the regulatory criteria for an RPA (USACE 2003a). Additionally, critical habitat had been designated for the piping plover, new information on the mortality of interior least terns and piping plovers was available, and an updated hydrology and hydraulics analysis indicated that some flow modifications could erode more emergent sandbar habitat (ESH) than they would create. In 2003, USFWS provided a determination that the new USACE proposed action would avoid jeopardizing the continued existence of the two listed bird species, but continued to appreciably reduce the likelihood of both survival and recovery of the pallid sturgeon, thus jeopardizing its continued existence in the wild (USFWS 2003a). USFWS then amended the 2000 BiOp to remove the flow modifications previously provided in the RPA, and concluded that mechanical and artificial creation for replacement of ESH were acceptable means to avoid a finding of jeopardy to the interior least tern and piping plover. The 2003 Amended BiOp retained the majority of RPA actions described in the 2000 BiOp; however, it added new RPA elements to the flow enhancement action. Fifteen new RPMs were provided in the 2003 amended BiOp replacing the RPMs in the 2000 BiOp to minimize take of interior least terns and piping plovers. USACE has since re-initiated consultation with the USFWS as part of this MRRMP-EIS process. A Final BA was submitted to USFWS on October 30, 2017 and a new Final BiOp was issued by USFWS on April 13, 2018 which determined that implementation of the USACE proposed action is not likely to jeopardize the pallid sturgeon, interior least tern, or piping plover. The preferred alternative in this EIS incorporates the proposed action in the 2017 BA and incorporates the 2018 BiOp.

Missouri River Recovery Program and the Missouri River Recovery Implementation Committee

The Missouri River Recovery Program (MRRP) was established by USACE in 2005. It is the umbrella program that coordinates the USACE efforts in the following:

- ESA compliance for the Operation of the Missouri River Main Stem Reservoir System, Operation and Maintenance of the BSNP, and Operation of the Kansas River Reservoir System;
- Acquiring and developing lands to mitigate for lost habitats as authorized in Section 601(a) of WRDA 1986 and modified by Section 334(a) of WRDA 1999 (collectively known as the BSNP Fish and Wildlife Mitigation Project); and
- Implementation of WRDA 2007 including the Missouri River Recovery Implementation Committee (MRRIC) and Section 3176, which allowed USACE to use recovery and mitigation funds in the upper basin states of Montana, Nebraska, North Dakota, and South Dakota.

MRRIC makes recommendations and provides guidance to federal agencies on the existing MRRP. MRRIC is composed of over 70 members representing various interests, Tribes, states, and agencies from within the Missouri River basin.

In 2011, MRRIC, USACE, and USFWS established the Independent Science Advisory Panel (ISAP). This panel is charged with providing independent science review, input, and advice on technical aspects of the MRRP when requested. The first topic charged to ISAP was Missouri River spring pulse management. The Final ISAP report, published in November 2011, found the spring pulse management action as implemented was not effective at achieving pallid sturgeon objectives and called for a more formal adaptive management plan. It also called for an analysis of the effects of USACE management actions on pallid sturgeon including further examination of various flow management actions and their relationship to habitat creation. Based on this report, MRRIC recommended seven actions to USACE and USFWS in August 2012:

1. An effects analysis should be developed that incorporates new knowledge accrued since the 2003 Amended BiOp. As part of this analysis:
   - The effects of the Missouri and Kansas River operations on the listed species should be reviewed and analyzed in the context of other stressors on the listed species;
   - The quantitative effects of potential management actions on the listed species should be documented to the extent possible; and
   - These potential management actions should be incorporated into the conceptual ecological models (CEMs).
2. CEMs should be developed for each of the three listed species and these models should articulate the effects of stressors and mitigative actions (including, but not limited to, flow management, habitat restoration actions, and artificial propagation) on species performance.
3. Other managed flow programs and adaptive management plans should be evaluated as guidance in development of the CEMs and adaptive management strategy.
4. An overarching adaptive management strategy should be developed that anticipates implementation of combined flow management actions and mechanical habitat construction. This strategy should be used to guide future management actions, monitoring, research, and assessment activities within the context of regulatory and legal constraints.
5. Monitoring programs along the Missouri River should be reviewed to determine whether hypothesized outcomes are occurring and the extent to which the outcomes are attributable to specific management actions.
6. The agencies should identify decision criteria (trigger points) that will lead to continuing a management action or selecting a different management action. A formal process should be designed and implemented to regularly compare incoming monitoring results with the decision criteria.
7. Aspects of how the entire hydrograph influences the three listed species should be evaluated when assessing the range of potential management actions.

Effects Analysis

USACE initiated an effects analysis subsequent to receiving the MRRIC recommended actions. The concept of an effects analysis is rooted in the requirement within the ESA to evaluate the effects of actions proposed by federal agencies on listed species or designated critical habitat, using the best available science. Completion of an effects analysis is preceded by problem formulation, which includes defining the proposed action, identifying the area affected, and developing conceptual models with written descriptions and visual representations of the physical and biological relationships between actions and species responses (Murphy and Weiland 2011). The effects analysis results and products informed the development of the MRRMP-EIS alternatives and the comprehensive adaptive management approach recommended by the ISAP.

Need for the Plan

Alteration of the ecosystem and loss of aquatic and terrestrial habitats due to USACE operation of the System and BSNP have contributed to the ESA-listing of the pallid sturgeon, piping plover, and interior least tern, species that inhabit the Missouri River. Compliance with the ESA is required to continue to operate the System and operate and maintain the BSNP. A substantial amount of new knowledge about the species, their habitats, and management opportunities has been developed since the 2003 Amended BiOp for the three listed species was published. As discussed previously, in 2011 the ISAP recommended developing a new adaptive management plan that would anticipate implementation of combined flow management actions and mechanical habitat construction. Under the ISAP recommendations, this new plan would be used to guide future management actions, monitoring, research, and assessment. The ISAP also recommended basing the Science and Adaptive Management Plan (SAMP) on an effects analysis, which would precede the development of the plan and incorporate new knowledge about the species accrued since the 2003 Amended BiOp (Doyle et al. 2011). Since the 2011 ISAP recommendation, effects analyses have been conducted for pallid sturgeon (Jacobson et al. 2016) interior least tern and piping plover (Buenau et al. 2018), and associated habitat analyses (Fischenich et al. 2018). The effects analysis synthesized and assessed new scientific information since the 2003 Amended BiOp. The emergence of this new information created a need for its evaluation and integration into USACE management actions on the Missouri River for the listed species and the associated SAMP.

The following sections describe the need for the proposed action relative to each listed species.

- **Pallid Sturgeon**: There is a demonstrated need to develop a management plan comprised of actions informed by best available science, as presented in the effects analysis that provides an adaptive framework to address the uncertainty associated with potential pallid sturgeon limiting factors. Development of a management plan which balances the substantial uncertainty regarding the beneficial effect of actions with the need to implement actions for a meaningful biological response is difficult and requires development of a robust adaptive management plan.
- **Interior Least Tern and Piping Plover**: As with the pallid sturgeon, there is a demonstrated need to develop a management plan comprised of actions informed by best available science, as presented in the effects analysis that provides an adaptive framework to address the uncertainty associated with piping plover and interior least tern management.

Purpose of the Plan

The purpose of this MRRMP-EIS is to develop a suite of actions that meets ESA responsibilities for the piping plover, the interior least tern, and the pallid sturgeon. Authorities used to meet this purpose may include existing USACE authorities related to Missouri River System operations for listed species and acquisition and development of land needed for creation of habitat for listed species provided by Section 601(a) of WRDA 1986, as modified by Section 334(a) of WRDA 1999, and further modified by Section 3176 of WRDA 2007 although alternatives formulation was not limited to these authorities.

Plan Objectives

USFWS provided fundamental objectives, sub-objectives, targets, and metrics for each of the three listed species pursuant to their responsibilities for administering the ESA, and special expertise as a cooperating agency on this MRRMP-EIS. These objectives were informed by the effects analysis products. Achieving these objectives would meet the purpose and fulfill the need of the plan.

Pallid Sturgeon Fundamental Objective: Avoid jeopardizing the continued existence of the pallid sturgeon from USACE actions on the Missouri River.

The following sub-objectives must be attained to ultimately achieve the stated “fundamental objective.” The intent of the sub-objectives is to provide direction in the short term, provide objectives meaningful for adaptive management, and focus efforts on the desired short-term outcomes while working toward the fundamental objective.

> **Pallid Sturgeon Sub-Objective 1**: Increase pallid sturgeon recruitment to age 1.
>
> **Pallid Sturgeon Sub-Objective 2**: Maintain or increase numbers of pallid sturgeon as an interim measure until sufficient and sustained natural recruitment occurs.

Piping Plover Fundamental Objective: Avoid jeopardizing the continued existence of the piping plover due to USACE actions on the Missouri River.

> **Piping Plover Sub-Objective 1 (Distribution)**: Maintain a geographic distribution of plovers in the river and reservoirs in which they currently occur in both the Northern and Southern River Regions.
>
> **Piping Plover Sub-Objective 2 (Population)**: Maintain a population of Missouri River piping plovers with a modeled 95 percent probability that at least 50 individuals will persist for at least 50 years in both the Northern and Southern Regions.
>
> **Piping Plover Sub-Objective 3 (Population Dynamics)**: Maintain a stable or increasing long-term trend in population size in both regions.
>
> **Piping Plover Sub-Objective 4 (Reproduction)**: Maintain fledgling production by breeding pairs sufficient to meet the population growth rate objectives within both the Northern and Southern Regions on the Missouri River.

Interior Least Tern Fundamental Objective: Avoid jeopardizing the continued existence of the endangered interior least tern due to USACE actions on the Missouri River.

For purposes of this MRRMP-EIS, it is assumed that achieving the stated objectives for the piping plover would also achieve the fundamental objective for the interior least tern.

Temporal and Geographic Scope

To facilitate plan development, an implementation timeframe of 15 years was chosen for this planning process and EIS. This is a reasonable timeframe for identification of actions which, based on the current state of the science, may provide meaningful biological responses while recognizing the potential, based on adaptive management, that substantive changes to the suite of actions identified in this MRRMP-EIS may be necessary in 15 years. However, effects to resources were based on an 82-year hydrologic period of record (POR) in order to provide an indication of the potential range of effects under the variable hydrologic conditions occurring in the Missouri River basin. The geographic scope of the federal action includes the Missouri River within its meander belt from Fort Peck Dam in Montana to its confluence with the Mississippi River near St. Louis, Missouri, and the Yellowstone River from Intake Dam at Intake, Montana to the confluence with the Missouri River.

Alternatives

The National Environmental Policy Act of 1969 (NEPA) requires federal agencies to evaluate and consider a range of reasonable alternatives that address the purpose of and need for action. Alternatives under consideration must include a “No Action” alternative in accordance with the President’s Council on Environmental Quality (CEQ) regulations (40 CFR 1502.14). As described in CEQ *Forty Most Asked Questions Concerning CEQ’s NEPA Regulations* (Question 3), “No Action” is best defined as “no change” from current management direction or level of management intensity in situations that involve updating management plans or ongoing programs. For this plan, the No Action alternative does not mean taking no action at all, it is a continuation of the actions currently being used to comply with the 2003 Amended BiOp (USFWS 2003). Differences between alternatives are shown by comparing the impacts of the No Action alternative and the action alternatives.

An interdisciplinary planning team made up of experts from multiple federal agencies in collaboration with basin stakeholders and Tribes participated in alternatives development. Alternatives were developed in accordance with the CEQ’s NEPA implementing regulations (40 CFR 1500-1508). The goal was to formulate a set of reasonable alternatives to meet the species objectives and clearly articulate the effects of those alternatives to provide necessary information to decision makers, stakeholders, Tribes and the public. The team used an iterative development process to identify and screen management actions and alternatives.

This EIS provides the necessary information for the decision maker to fully evaluate a range of alternatives to best meet the purpose and need of the MRRMP. It fully addresses the potential impacts of alternatives as required under the NEPA, as amended (42 U.S. Code (USC) 4321 et seq.); CEQ regulations (40 CFR 1500 – 1508); and USACE ER 200-2-2 (33 CFR 230). This plan will be reviewed on a regular basis to ensure compliance with applicable laws and regulations, and that circumstances have not changed that would impact the analysis and conclusions reached in the document.

Plan Alternatives Carried Forward for Detailed Evaluation

Six plan alternatives (the No Action alternative and five action alternatives) were carried forward for detailed evaluation. The names of each alternative correspond to the concept or feature that distinguishes them from all other alternatives. Some of the alternatives share management actions.

Actions Common to All Plan Alternatives

The following management actions would be implemented as part of all plan alternatives carried forward for detailed evaluation in this MRRMP-EIS including the No Action alternative.

- **Mechanical Emergent Sandbar Habitat (ESH) Construction for Piping Plovers and Least Terns**: All alternatives include mechanical ESH construction as a management action; however, the amounts of ESH that would be constructed mechanically vary by alternative and those differences are described in the respective section for each alternative.
- **Vegetation Management, Predator Management, and Human Restriction Measures to benefit Piping Plovers and Least Terns**: The primary and preferred method of vegetation control and removal is application of pre- and/or post emergent herbicides to selected sandbars. Additional vegetation control and removal methods include controlled burning, cutting, mulching, and mowing. Predator management actions include the lethal or non-lethal

removal of predators. Targeted species such as raccoons, coyotes, mink, and great horned owls are either lethally or non-lethally removed depending on the species and situation. Indirect management actions may include caging, fencing, or hazing which dissuades predators from breeding sites and are deployed when predation activities are present but not severe. Nests at risk of predation are primarily protected by placing exclosure cages around them. Exclosure cages can only be used to protect piping plover nests; least terns frequently fly to and from their nests and are less likely to walk through the enclosure.

Human restriction measures taken to reduce disturbance to the birds include posting signs and placing barricades to restrict access to breeding areas and outreach efforts.

- **Flow Management to Reduce Take of Piping Plovers and Least Terns**: This action involves the adjustment of reservoir releases during the nesting season to reduce take of nests, eggs, and/or chicks by rising water levels. It is referred to as Steady Release-Flow to Target and is a current management practice that would continue under each of the alternatives.
- **Piping Plover and Least Tern Monitoring and Research**: USACE conducts annual productivity monitoring of least tern and piping plover populations on the reservoir and river reaches of the Missouri River Mainstem. The monitoring focuses on an adult census, measurement of fledge ratios, and documentation of incidental take. USACE also performs habitat monitoring. Monitoring results are used to determine the effectiveness of management actions for least terns and piping plovers. In addition, USACE funds focused research projects on various aspects of least tern and piping plover demographics and habitat use.
- **Pallid Sturgeon Propagation and Augmentation**: The authority and responsibility for hatchery management lie with the USFWS for those facilities operated by the USFWS; states are responsible for the operation of their hatcheries. USACE support of pallid sturgeon propagation and augmentation efforts would continue at current levels under all plan alternatives.
- **Pallid Sturgeon Population Assessment Project**: The Pallid Sturgeon Population Assessment Project (PSPAP) has been the primary fish monitoring element for the BiOp and the MRRP and would continue in some form under all plan alternatives. Data collected through the PSPAP are used to provide long-term assessment of pallid sturgeon metrics.
- **Monitoring and Evaluation of Pallid Sturgeon Recruitment**: Under all plan alternatives, USACE would conduct the monitoring and assessment complimentary of that for which the Bureau of Reclamation has responsibility to determine if modifications for fish passage at Intake Diversion Dam are meeting pallid sturgeon objectives. The Bureau of Reclamation is responsible for monitoring the success of fish passage at Intake following implementation of fish passage measures. USACE would be responsible for ensuring that MRRP monitoring and assessment can determine if successful fish passage at Intake is contributing to the upper river pallid sturgeon population.
- **Lower River Pallid Sturgeon Early Life Stage Habitat Construction**: All plan alternatives include channel reconfiguration for the creation of early life stage pallid sturgeon habitat; however, the amounts and types of habitat that would be created vary by alternative and those differences are described in the respective section for each alternative. This action includes the physical manipulation of the river bed or bank to create or improve areas for provision of specific pallid sturgeon habitats thought to be limiting. Examples include adjustments to navigation training or bank stabilization structures, channel widening (i.e., top-width widening), floodplain modifications or other adjustments to channel geometry, placement of structures to encourage development of needed habitat or habitat complexity, chute development, or adjustments to existing chutes.

- **Habitat Development and Land Management on MRRP Lands**: All plan alternatives include habitat development and land management on MRRP lands; however, the amount of land acquisition varies by alternative as would the magnitude of this action. The land requirements for implementation of habitat creation can occur (1) on existing public lands if the state or federal agency owning the property is willing to cooperate with USACE on the project; or (2) on land acquired in fee title from willing sellers.

Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)

Under the No Action alternative, the MRRP would continue to be implemented as it is currently. In addition to the description of actions common to all plan alternatives the USACE would implement the following under Alternative 1:

- **Mechanical ESH Construction**: USACE would mechanically construct ESH annually at an average rate of 164 acres per year across the Garrison and Gavins Point reaches.
- **Early Life Stage Habitat Construction for Pallid Sturgeon**: Under the No Action alternative, construction of habitat to support early life stage requirements of pallid sturgeon would occur as part of the shallow water habitat (SWH) program. The SWH restoration goal as outlined in the 2003 Amended BiOp (USFWS 2003) is to achieve an average of 20–30 acres of SWH per river mile. Under the No Action alternative, the USACE would achieve the low end of this acreage target (i.e., 20 acres per river mile between Ponca, Nebraska, and the mouth).
- **Spawning Cue Release for Pallid Sturgeon**: For purposes of modeling the No Action alternative, USACE assumed implementation of the plenary spring pulse as described in the Master Manual (USACE 2006) would occur. This action would include a March and May Spring Pulse from Gavins Point Dam.
- **Monitoring, Research and Adaptive Management**: In addition to the PSPAP described under actions common to all plan alternatives it was also assumed that other current USACE monitoring and research programs for pallid sturgeon would continue including the Habitat Assessment and Monitoring Program (HAMP) and focused pallid sturgeon research. USACE would also continue to implement the adaptive management approach that has been in place since 2009. It consists of two primary components: the Adaptive Management Plan for ESH (USACE 2011) and the adaptive management strategy developed for SWH creation (USACE 2012c).

Alternative 2 – U.S. Fish and Wildlife Service 2003 Biological Opinion Projected Actions

Alternative 2 represents the USFWS interpretation of the management actions that would be implemented as part of the 2003 Amended BiOp RPA (USFWS 2003). Whereas the No Action alternative only includes the continuation of management actions the USACE has implemented to date for BiOp compliance, Alternative 2 includes additional iterative actions and expected actions that USFWS anticipates would ultimately be implemented through adaptive management as impediments to implementation were removed. In addition to the description of actions common to all plan alternatives the USACE would implement the following under Alternative 2:

- **Mechanical ESH Construction**: USACE would mechanically construct an average of 1,331 acres of ESH annually across the Garrison, Fort Randall, Gavins Point, and Lewis and Clark Lake reaches.
- **Spring Habitat-Forming Flow Release**: A spring reservoir release for the purposes of ESH is not included in Alternative 2; however, the timing and magnitude of the pallid sturgeon spring flow release would provide ESH creating benefits which were accounted for in the habitat modeling.

- **Lowered Nesting Season Flows**: The low summer flow described for pallid sturgeon would also serve as a lowered nesting season flow for the benefit of least terns and piping plovers under Alternative 2.
- **Early Life Stage Habitat Construction for Pallid Sturgeon**: Under Alternative 2, the USACE would achieve the high end of the 2003 Amended BiOp acreage target (i.e., 30 acres per river mile between Ponca, Nebraska, and the mouth).
- **Spring Pallid Sturgeon Flow Release**: USFWS determined in the 2003 Amended BiOp that restoration of a normalized river hydrograph below Gavins Point Dam was necessary to avoid jeopardizing the continued existence of the pallid sturgeon. Several biologically relevant features were identified for a flow action below Gavins Point Dam including (1) flows to cue spawning that are sufficiently high for an adequate duration; and (2) flows that provide for connection of low-lying lands adjacent to the channel. The spring pallid sturgeon flow release from Gavins Point Dam would be bimodal (i.e., consisting of two separate flow pulses) and would be implemented in every year if conditions are met.
- **Low Summer Flow**: The USFWS 2003 Amended BiOp also called for modification of System operations to allow for flows that are sufficiently low to provide for SWH as rearing, refugia, and foraging areas for larval, juvenile, and adult pallid sturgeon. Alternative 2 includes a low summer flow that would be implemented to meet those purposes.
- **Floodplain Connectivity**: The USACE coordinated with the USFWS during alternatives development to identify criteria for clarification of the floodplain connectivity management action stated in the USFWS 2003 Amended BiOp. The criteria submitted to the USACE from the USFWS for Alternative 2 stated that this management action should maximize floodplain habitat by ensuring that 77,410 acres of connected floodplain are inundated at a 20 percent annual chance exceedance.
- **Monitoring, Research and Adaptive Management**: Monitoring and research efforts under Alternative 2 would be the same as described for Alternative 1. The adaptive management approach for Alternative 2 was assumed to be similar to the adaptive management approach that USACE has been implementing since 2009 and described for Alternative 1. The adaptive management approach for Alternative 2 would be the same as for Alternative 1 but would be modified to address specific alterations in proposed management actions as described by the USFWS in a November 5, 2015, Planning Aid Letter to the USACE.

Alternative 3 – Mechanical Construction Only

Under Alternative 3, current System operations as described in the Master Manual would continue except the spring plenary pulse and reservoir unbalancing would not be implemented. In addition to the description of actions common to all plan alternatives the USACE would implement the following under Alternative 3:

- **Early Life Stage Habitat Construction**: Under Alternative 3, construction of habitat to support early life stage requirements of pallid sturgeon would occur following the IRC (interception and rearing complex) concept. During the first 6–7 years of implementation, 12 site pairs (experimental IRC site and control site) would be implemented in an experimental design to evaluate whether young fish are intercepted and retained. In addition to the IRC experiment, existing SWH sites would be evaluated to determine if they are presently functioning as IRC habitat. Those that can be most efficiently modified to provide IRC habitat would be refurbished.
- **Spawning Habitat Construction**: Under Alternative 3, USACE would construct up to three spawning habitat sites and monitor the effectiveness of this action in terms of the relative use of these sites compared to other control areas, and the relative spawning success, as determined by hatch rate, catch per unit effort of free embryos, and other indicators.

- **Mechanical ESH Construction**: Under Alternative 3, the USACE would only create ESH habitat through mechanical means at an average rate of 332 acres per year, in years where construction is needed, across the Garrison, Fort Randall, and Gavins Point reaches. This amount represents the acreage necessary to meet the bird habitat targets after accounting for available ESH.
- **Level 1 and 2 Studies**: As part of the SAMP, USACE would implement Level 1 and 2 studies for better understanding of limiting factors associated with pallid sturgeon. Level 1 studies are research focused and do not change river conditions (laboratory studies or field studies under ambient conditions). Level 2 studies would focus on in-river testing of actions at a level sufficient to expect a measurable biological, behavioral, or physiological response in pallid sturgeon, surrogate species, or related habitat response. The one-time spawning cue test (Level 2) release that may be implemented under Alternatives 3, 4, and 5 was not included in the hydrologic modeling for these alternatives because of the uncertainty of the hydrologic conditions that would be present if implemented. Hydrologic modeling for Alternative 6 simulates reoccurring implementation (Level 3) of this spawning cue over the wide range of hydrologic conditions in the POR. Therefore, the impacts from the potential implementation of a one-time spawning cue test release would be bound by the range of impacts described for individual releases under Alternative 6.
- **Adaptive Management**: Under Alternative 3, the USACE would follow the Science and Adaptive Management Plan (SAMP) that was developed based on the results of the effects analysis. The SAMP is a companion document to the MRRMP-EIS. The SAMP identifies the process and criteria to implement the initial management actions, assess hypotheses, introduce new science, and provide a process for adjusting management actions should it become necessary.

Alternative 4 – Spring ESH Creating Release

Alternative 4 includes those actions identified as common to all alternatives and also includes the adaptive management approach described for Alternative 3, Level 1 and 2 studies, spawning habitat construction, and early life stage pallid sturgeon habitat as specified under Alternative 3. The spring ESH-creating flow release is the management action unique to Alternative 4.

- **Spring ESH Creating Release**: Alternative 4 would include a high spring release designed to create ESH for piping plovers and least terns. In any year, the implementation of this release would occur if System storage is at 42 MAF or greater on April 1, natural flows creating 250 acres of ESH have not occurred in the previous 4 years, and downstream flow limits are not exceeded.
- **Mechanical ESH Construction**: The average amount of ESH that would need to be constructed under Alternative 4 is less than Alternative 3 because of ESH created by the spring release. Alternative 4 would include the construction of an average of 195 acres annually across the Garrison, Fort Randall, and Gavins Point reaches in years where construction is needed.

Alternative 5 – Fall ESH Creating Release

Alternative 5 includes those actions identified as common to all alternatives and also includes the adaptive management approach described for Alternative 3, Level 1 and 2 studies, spawning habitat construction, and early life stage pallid sturgeon habitat as specified under Alternative 3. The fall ESH-creating flow release is the management action unique to Alternative 5.

- **Fall ESH Creating Release**: Alternative 5 would include a high fall release designed to create ESH for piping plovers and least terns. In any year, the implementation of this release would occur on October 17 if System storage is at 54.5 MAF or greater, natural flows creating 250 acres of ESH have not occurred in the previous 4 years, and downstream flow limits are not exceeded.

- **Mechanical ESH Construction**: The average amount of ESH that would need to be constructed under Alternative 5 is less than Alternative 3 because of ESH created by the fall release. Alternative 5 would include the construction of an average of 253 acres per year in across the Garrison, Fort Randall, and Gavins Point reaches in years where construction is needed.

Alternative 6 – Pallid Sturgeon Spawning Cue

Alternative 6 includes those actions identified as common to all alternatives and also includes the adaptive management approach described for Alternative 3, Level 1 and 2 studies (except one-time spawning cue test release), spawning habitat construction, and early life stage pallid sturgeon habitat as specified under Alternative 3. The spring pallid sturgeon spawning cue flow release is the management action unique to Alternative 6.

- **Spring Pallid Sturgeon Spawning Cue Flow Release**: Alternative 6 would attempt a spawning cue release every 3 years consisting of a bimodal pulse in March and May. These spawning cue releases would not be started or would be terminated whenever downstream flow limits are reached.
- **Mechanical ESH Construction**: The average amount of ESH that would need to be constructed under Alternative 6 is less than Alternative 3 because of incidental ESH created by the spring spawning cue release. Alternative 6 would include the construction of an average of 246 acres per year across the Garrison, Fort Randall, and Gavins Point reaches in years where construction is needed.

Summary of Key Uses / Resources and Impacts Assessment Methods

The management actions in this MRRMP-EIS that could potentially affect the environment are generally construction-type activities or changes in reservoir System releases. In addition to understanding the temporary or short-term impacts that could result from these actions, it is prudent to consider long-term impacts that could occur in conjunction with the substantial hydrologic variability that exists in the Missouri River basin. Therefore, the discussion of potential impacts for many resources includes an analysis based on the results of modeling the alternatives over an 82-year (1931−2012) hydrologic POR for the Missouri River basin.

The USACE Hydrologic Engineering Center River Analysis System (HEC-RAS) model uses the outputs of the Reservoir System Simulation (ResSim) model to calculate river flow and water surface elevations of the Missouri River that were routed down the Missouri River Mainstem, through thousands of river cross sections and hundreds of miles to the mouth at St. Louis. The HEC-RAS model geometry and calibration were generally representative of 2012 conditions and revised to reflect the potential extent of early life stage pallid sturgeon habitat for each alternative. It was assumed this revised geometry was in place every year of the POR.

One might expect the modeling output for the No Action alternative (which reflects existing operation of the System and current implementation of MRRP actions) from either ResSim or HEC-RAS to match actual observed conditions. However, this is not the case. The following is a description of the primary reasons why the modeled outputs for the No Action alternative do not match what actually occurred in the past.

- **Operational Differences**: The No Action alternative is a simulation of how the System is currently operated, including current MRRP actions, but does not and cannot take into account the numerous minor adjustments to basic rules that the USACE actually makes to reasonably address critical short-term situations (e.g., increase releases for water supply, reducing releases for ice jams, etc.) In addition to the short-term changes, the basic operational rules have changed throughout the POR. For example, drought conservation criteria have been changed as recently as 2004 and were included in simulating operation for the entire POR.

- **River Geometry Changes**: The bed profile of the Missouri River is constantly changing: eroding ("degrading") in some places and accumulating ("aggrading") in others. Long-term stage trends not associated with the management actions included in the alternatives are known to be occurring in many locations under existing operation. For the purposes of comparing the effects of the alternatives, the models were developed with the best available survey data and calibrated to the 2012 condition. This geometry was assumed for each year of the POR.
- **Depletions**: All historic POR runoff levels were adjusted for consumptive water use to the current level of depletions. Depletions consist of water use by irrigation, municipal, evaporation, etc. This assumes the current 2012 level of water use projected from 1931 including evaporation from the Mainstem reservoirs.

Therefore, modeling results of the No Action alternative do not reflect actual past or future conditions but serve as a reasonable basis or "baseline" for comparing the impacts of the action alternatives on resources.

The POR is characterized by substantial variability in hydrologic conditions, which includes periods of drought (e.g., 1930s) and high runoff (e.g., 1997, 2011). This hydrologic variability results in substantial changes to resources and uses over the POR with all the alternatives, including the No Action alternative. These changes are not associated with the species management actions included in the alternatives, and therefore the following impact analyses are focused on comparing the difference the action alternatives have on resources compared to the No Action alternative. The "rules" governing System operation during periods of drought and high runoff for the action alternatives are generally the same as current System operation under the No Action alternative. Therefore, the effects of the action alternatives on reservoir elevations and releases are relatively small compared to the variation caused by the extreme hydrologic events in the POR.

Relative differences among the alternatives are important to understand. The MRRMP-EIS affected environment and environmental consequences chapter (Chapter 3) presents the relative impacts of each alternative on each specific resource in order to focus on this perspective. Summary descriptions of each resource topic are presented below followed by a summary table of the environmental consequences of the different alternatives.

River Infrastructure and Hydrologic Processes

The flow of the Mainstem Missouri River is influenced by precipitation and seasonal snowmelt that occurs throughout the basin, as well as flow regulation from Mainstem dams. Total annual runoff from the Missouri River varies considerably from year to year because of large variations in precipitation. The magnitude, frequency, timing, duration, and rates of change of river flows affect the geomorphology, chemistry, human resources, and biological processes in the Missouri River. Groundwater elevation is a key factor in the composition and spatial distribution of vegetation communities and their associated fauna across the floodplain. The operation of the System is guided by the Master Manual (USACE 2006a). This Master Manual records the basic water control plan and objectives for the integrated operation of the Mainstem reservoirs. The reservoir stage and flow releases vary throughout the year as a result of reservoir operations that follow the Master Manual.

The analysis of impacts of the alternatives to river infrastructure and hydrologic processes focuses on the impacts to hydrology, geomorphology, and infrastructure in the river, as well as groundwater along the river. Primary geomorphological processes that are relevant for the proposed management actions consist of degradation and bank erosion, reservoir sediment deposition and aggradation, reservoir shoreline erosion, and ice dynamics.

Alternatives 1, 2, and 4–6 would result in temporary and long-term adverse impacts from flow releases to river infrastructure and hydrologic processes. All alternatives could result in adverse impacts from habitat construction in the upper river. None of the alternatives is expected to result in significant impacts. For a more detailed summary related to potential impacts to river infrastructure and hydrologic processes, see the environmental consequences summary table below and the full description of river infrastructure and hydrologic processes impacts analysis methods and results in Section 3.2.

Pallid Sturgeon

The pallid sturgeon was listed as endangered under the ESA on September 6, 1990 (55 FR 36641–36647). A recent revision of the species recovery plan notes that the species status has improved and is currently stable as a result of artificial propagation and stocking efforts (USFWS 2014). If stocking were to cease, pallid sturgeon would face local extirpation in several reaches of the Missouri River (USFWS 2014). USFWS (2014) states that pallid sturgeon will be considered for reclassification from endangered to threatened when the listing/recovery factor criteria are sufficiently addressed such that a self-sustaining, genetically diverse population of 5,000 adult pallid sturgeon is realized and maintained within each management unit for two generations (20–30 years). The potential impacts of each alternative on the Missouri River pallid sturgeon population were assessed with special emphasis on the potential to increase survival of age-0 pallid sturgeon and increase recruitment.

All of the action alternatives analyzed were developed to provide benefits to pallid sturgeon. Therefore, none of the alternatives would result in significant adverse impacts. Although alternatives vary in the amount of habitat created, the construction of ESH and IRC could result in temporary adverse impacts. However, these impacts are not expected to result in population-level changes. For a more detailed summary related to potential impacts to pallid sturgeon, see the environmental consequences summary table below and the full description of pallid sturgeon impacts analysis methods and results in Section 3.3.

Piping Plover and Interior Least Tern

The Northern Great Plains piping plover was listed as threatened in 1985, under provisions of the ESA (USFWS 1985). The breeding population of the piping plover extends from Nebraska north along the Missouri River through South Dakota, North Dakota, and eastern Montana, and on alkaline lakes along the Missouri River Coteau in North Dakota, Montana, and extending into Canada. Interior least terns were listed as endangered under the ESA in 1985 (USFWS 2013). The breeding population of least terns extends across the interior of the United States along the Mississippi, Missouri, and Rio Grande Rivers and their tributaries. Nesting habitat for both species includes sparsely vegetated river sandbars, sandpits, and reservoir beaches. The USFWS provided objectives, metrics, and targets for the Northern Great Plains piping plover under the MRRMP-EIS with the assumption that managing for sufficient nesting habitat to sustain a Northern Great Plains piping plover population in the Missouri River will also provide sufficient nesting habitat for the interior least tern in the Missouri River (USFWS Planning Aid Letter 2015).

A habitat/population model was used to evaluate the effectiveness of the proposed management actions and alternatives at meeting the objectives for the piping plover and least tern. ESH was calculated for each alternative along with the following metrics:

- Number of adults
- Number of fledglings
- Fledge rate

- Population growth rate
- Extinction probability (throughout the geographic scope, north region, and south region)

Each action alternative would benefit piping plovers and least terns compared to Alternative 1. Alternative 1 would not meet the updated ESH targets or the population persistence objective. However, Alternative 2 would exceed the updated ESH targets and persistence objective. Alternatives 3–6 would all meet the ESH targets and therefore result in the same beneficial impacts on piping plovers and least terns. None of the alternatives would result in significant impacts. For a more detailed summary related to potential impacts to piping plovers and least terns, see the environmental consequences summary table below and the full description of piping plover and least tern impacts analysis methods and results in Section 3.4.

Fish and Wildlife Habitat

The Missouri River and its floodplain have historically consisted of a multitude of aquatic and terrestrial habitat types that sustained rich assemblages of fish and wildlife species. These assemblages include species that live year-round within the river and its floodplain as well as migratory species for which the ecosystem provides vital seasonal habitat (e.g., wintering and breeding), movement corridors, and stopover habitats. Aquatic habitats generally include open water habitats of varying depths (i.e., main channel, secondary channels and chutes, backwaters, floodplain lakes/oxbows). Terrestrial habitats include emergent wetlands, forests, woodlands, grasslands, and shrublands.

The environmental analysis for fish and wildlife focused on potential changes in terrestrial and aquatic habitat and considered the actions included under each alternative and their impacts to fish and wildlife habitats. Fish and wildlife habitat metrics were modeled within eight study reaches within two larger geographic regions, upstream of Gavins Point Dam to Fort Peck Dam, and downstream from Gavins Point Dam to the confluence with the Mississippi River. The eight smaller study reaches are based on logical divisions within the existing Missouri River (e.g., inter-reservoir reaches) or broad ecological similarities. For the purposes of the model, habitats were broadly categorized into six types (open water, emergent wetland, scrub shrub wetland, riparian woodland/forested wetland, forest, and upland grasslands). The results of the modeling effort only reflect the modeled flow actions, simulated conditions on the river, and associated constraints as defined under the alternatives.

All of the alternatives analyzed would result in long-term benefits to fish and wildlife from habitat creation and short-term adverse impacts related to construction activity. None of the alternatives would result in significant adverse impacts to fish and wildlife. For a more detailed summary related to potential impacts to fish and wildlife, see the environmental consequences summary table below and the full description of fish and wildlife impacts analysis methods and results in Section 3.5.

Other Special-Status Species

The MRRMP-EIS assesses the potential impacts to special status species that could occur in the Missouri River and its floodplain in several ways. The EIS provides a general analysis of these species and the potential impacts that could occur from the alternatives being considered, but provides a more specific analysis of three species that were identified based on the potential for impacts that could occur to individuals, populations, or their habitat in areas where management could occur. These species include: bald eagle, northern long-eared bat, and Indiana bat. These species were identified because of their association with habitats in the Missouri River and its floodplain.

Impacts were analyzed based on changes to the habitat associated with the species. The associated habitat was based on the fish and wildlife habitat classes modeled in all study reaches for the POR. Thus, habitat impacts were used as a proxy for impacts to other special-status species.

All alternatives would result in temporary, adverse impacts to bald eagles, Indiana bats and northern long-eared bats from mechanical ESH and early life stage pallid sturgeon habitat construction. However, all alternatives would also result in long-term benefits from land acquisition and habitat development, though benefits would vary based on alternatives and amount of land acquired. None of the alternatives would result in significant adverse impacts. For a more detailed summary related to potential impacts to other special-status species, see the environmental consequences summary table below and the full description of other special-status species impacts analysis methods and results in Section 3.6.

Water Quality

Water quality and sources of pollution can vary greatly along the length of Missouri River. Humans have modified the Missouri River ecosystem and the resulting changes in land uses, landscape cover types, and their associated nutrient and pollutant sources within the basin influence water quality. The primary sources of pollution, both point and nonpoint sources, along the Missouri River are from urban, agricultural, and industrial land uses. The construction of the dams and impoundments trap suspended sediment and particulates, modify the flow regime of the river, and influence water quality within the reservoirs and the downstream free-flowing reaches. Additionally, the natural river flows, stages, and channel geometry can influence water quality within the river. The physicochemical water quality parameters identified for assessment include: water temperature, dissolved oxygen, nutrients (nitrogen and phosphorus), sediment and turbidity, and other pollutants including metals/metalloids. These parameters are common water quality assessment metrics and are important for the health of ecological communities and the human uses of the river.

Temporary, adverse impacts could occur from increased sediment and turbidity, nutrients, pollutants, water temperatures, and lower dissolved oxygen concentrations. In the long term, habitat development actions and construction of early life stage habitat would benefit local water quality by decreasing nutrient and other pollutant levels. None of the alternatives would result in significant impacts on water quality. For a more detailed summary related to potential impacts to water quality, see the environmental consequences summary table below and the full description of water quality impacts analysis methods and results in Section 3.7.

Air Quality

The main causes of air pollution include mobile sources such as automobile emissions along major highways as well as stationary sources such as coal-fired power plants. Other sources include diesel-powered watercraft and various industrial emissions in heavy urbanized areas such as Kansas City, Omaha, and Sioux City (EPA 2015a). Six designated non-attainment and partial non-attainment areas exist within the lower portion of the river in Pottawattamie County, Iowa and in Missouri in Franklin County, St. Charles County, Jackson County, St. Louis County, and St. Louis City.). Greenhouse gasses are also produced from mobile sources in the project area. These sources include motor vehicles such as trucks and boats utilized for transportation of goods and materials along the Missouri River. Emissions from these vehicles impact regional air quality incrementally through contributions to levels of criteria air pollutants such as carbon monoxide, nitrogen oxide, and volatile organic compounds.

The analysis of impacts to air quality considers the potential for actions to adversely affect air quality through emissions from mobile sources of criteria air pollutants and the contribution to greenhouse gas emissions associated with habitat construction. The impacts from management actions on air quality are common to all alternatives and are not assessed individually for each alternative. Under all alternatives, localized adverse impacts to air quality from construction-related emissions would occur, but would be limited to periods of active habitat construction. For a more detailed summary related to potential impacts to air quality, see the environmental consequences summary table below and the full description of air quality impacts analysis methods and results in Section 3.8.

Cultural Resources

The USACE Planning Guidance Notebook (ER 1105-2-100) defines cultural resources in terms of "historic properties" as follows:

> [A] historic property is any prehistoric or historic district, site, building, structure or object included in or eligible for inclusion on the National Register of Historic Places (National Register). Such properties may be significant for their historic, architectural, engineering, archeological, scientific, or other cultural values, and may be of national, regional, state, or local significance. The term includes artifacts, records, and other material remains related to such a property or resource. It may also include sites, locations, or areas valued by Native Americans, Native Hawaiians, and Alaska Natives because of their association with traditional religious or ceremonial beliefs or activities.

USACE has a federal compliance and stewardship responsibility to ensure the preservation and protection of cultural resource sites located on federal lands and for historic properties that may be affected by USACE undertakings, as outlined in the National Historic Preservation Act of 1966 (NHPA) and other pertinent laws, regulations, and policies, as described in Chapter 6 of this EIS. Numerous cultural resource sites have been identified within the Missouri River Basin. Most of these cultural resource sites are archaeological sites, burials, historic buildings or structures, and/or shipwrecks. Within the upper Missouri River Basin, USACE has inventoried the Mainstem Reservoir System. State Historic Preservation Offices (SHPOs) within the basin provided inventory data for sites in riverine settings (i.e., downstream of Gavins Point Dam, as well as riverine reaches between the Mainstem reservoirs). These inventories of cultural resource sites in riverine settings (developed largely through an accumulation of site-specific compliance with NHPA) are less thorough than the inventories at the reservoirs. The analysis of effects on cultural resources differentiated two categories of cultural resource sites. "Reservoir sites" were sites located on federal fee-owned lands of the six USACE-managed Missouri River Mainstem reservoirs. "Riverine sites" included sites located within the bluff-to-bluff Missouri River floodplain that were not already included in the inventories of USACE-managed Missouri River Mainstem reservoir sites. These riverine sites are located in the Missouri River floodplain south of Gavins Point Dam and on sections of the river between the Mainstem reservoirs. Impacts were primarily assessed in relation to modifications of flow and changes in reservoir pool elevations that could change the frequency of risk of erosion and/or vandalism and looting.

All of the alternatives evaluated would result in localized, long-term, adverse impacts to cultural resources at both reservoir and riverine sites. Alternative 2 would result in the largest adverse impacts compared to the other alternatives considered. For a more detailed summary related to potential impacts to cultural resources, see the environmental consequences summary table below and the full description of cultural resources impacts analysis methods and results in Section 3.9.

Land Ownership

Land ownership within the Missouri River floodplain includes federal, state, and local government lands, Tribal lands, and private lands. Various land uses are present within the Missouri River floodplain, including developed lands, agricultural lands, open water, and other types of use. Developed lands refers to communities, towns, and cities, including commercial, industrial, and residential uses, as well as lands developed to support transportation (highways, roads, bridges, railroads) and other infrastructure. Agriculture is the dominant land use in the floodplain between Gavins Point Dam and the mouth, accounting for between 63 to 72 percent of floodplain land. Federal conservation lands and lands managed for natural habitat and recreation include those administered under the USACE MRRP, U.S. National Park Service lands, and USFWS National Wildlife Refuge lands, among others. There are also state and local government-owned lands, Tribal lands, and private lands managed for conservation and recreation within the floodplain.

The impacts resulting from the federal government acquiring lands from willing sellers to construct pallid sturgeon early life stage habitat are evaluated using two of the planning accounts: regional economic development (RED) and other social effects (OSE).

Alternatives 1 and 2 would result in long-term, adverse impacts to RED, in terms of employment and labor income, and OSE. If the concentration of acquired lands over the implementation period is concentrated in a small number of locations in a rural region with limited economic activity, the adverse impacts could be disproportionate in relation to that small economy. Alternatives 3–6 would result in long-term benefits to RED, compared to Alternative 1, as less land would be acquired. None of the alternatives would result in significant impacts. For a more detailed summary related to potential impacts to land ownership, see the environmental consequences summary table below and the full description of land ownership impacts analysis methods and results in Section 3.10.

Commercial Sand and Gravel Dredging

The volume of commercial sand and gravel dredged on the Missouri River fluctuates annually based on economic conditions (primarily market demand), availability of materials in the river system, and other factors. Approximately 92 percent of commercial sand and gravel from the Missouri River is used for residential and nonresidential construction (excluding state transportation projects). Commercial sand and gravel production primarily serves 40 counties across the three states of Kansas, Missouri, and Iowa, with a population of nearly 5.1 million.

River flows, the volume of water in the river, and sediment conditions directly affect whether dredges are able to operate and how much sediment is being transported for extraction. Changes in those physical conditions can directly affect access to sand and gravel.

The commercial sand and gravel dredging impacts analysis focuses on determining if changes in river and reservoir conditions or the construction of habitat could result in an impact to commercial sand and gravel dredging operations.

None of the alternatives evaluated would have a noticeable adverse impact on the sediment accumulation available for dredging. In addition, given the very small percentage of affected tonnage and availability of other sites to conduct commercial sand and gravel dredging, it is anticipated that adverse impacts from the construction of habitat sites to commercial sand and gravel dredging would not be significant. For a more detailed summary related to potential impacts to commercial sand a gravel dredging, see the environmental consequences summary table below and the full description of commercial sand and gravel dredging impacts analysis methods and results in Section 3.11.

Flood Risk Management and Interior Drainage

A main objective of Mainstem Reservoir System is to regulate the reservoirs to reduce the risk of flood damage in the reaches downstream from dams. Regulation of individual reservoirs is coordinated to reduce flood risk from a particular reservoir. The usual reservoir operation is to store flood inflows, which generally extend from March through July, and to release them during the remainder of the year. Most of these releases are made before December. Winter releases are restricted due to the formation of ice bridges and the associated higher river stages. The objective is to have reservoir levels lowered to the bottom of the annual flood control and multiple use zone by March 1 of each year. Upstream from Gavins Point, releases from Fort Peck, Garrison, Oahe, and Fort Randall Dams are reduced during periods of ice formation until an ice cover is formed, after which releases can be gradually increased. Minimal ice problems exist directly downstream from Big Bend Dam due to its proximity to Lake Francis Case. Operation of the reservoirs for flood risk management must take into account highly variable flows from numerous tributaries. During any flood season, the existence of upstream tributary storage reduces mainstem flood volumes to some extent. Normally, the natural crest flows on the Mainstem reservoirs will also be reduced by the existence of tributary reservoir storage, provided significant runoff contributing to the crest flows originates above the tributary projects.

Levees also play a role in flood risk management along the Missouri River. Federal levee construction in accordance with the 1941 and 1944 Flood Control Acts began in 1947. Most existing federal levees are in the reach located between Omaha and Kansas City. The levees help to manage flood risk to these localities during the most severe flood events of record. Between Sioux City and the mouth of the Missouri River, local interests have built many miles of levees, consisting of about 500 non-federal levee units through this reach of the river. Most of these levees are inadequate to withstand major floods, but generally provide flood risk management for events smaller than a 20 to 5 percent annual chance of exceedance event (20-year).

Agricultural lands within the landward side of federal levee areas are affected by the ability to drain interior runoff into the Missouri River. High water can result in poor drainage, higher groundwater, blocked access, and associated damage and inconvenience. Hundreds of individual gravity drainage structures (e.g., culverts with flap gates) and pumping plants exist along levees near the Missouri River. The USACE Kansas City and Omaha districts have survey data on approximately 1,400 individual interior drainage structures across approximately 115 Missouri River levee segments. Most of the interior drainage issues occur along leveed areas below Omaha to the mouth of the Missouri River, with over 70 percent of the flap gates located between Rulo and the mouth of the Missouri River.

Land, property (both urban and rural), infrastructure, and people in the floodplain can be affected by Missouri River flooding. Approximately 173,000 people reside along the Missouri River floodplain with the majority of these populations living in the lower river, including the cities of Omaha, Council Bluffs, St. Joseph, Kansas City, and St. Louis. There are over 62,000 residential and 11,400 nonresidential structures in the floodplain. The total estimated value of these structures and their contents is $59.5 billion. The Missouri River from Fort Peck to the mouth of the Missouri River was divided into ten reaches: Fort Peck Dam to Garrison Dam, Garrison Dam to Oahe Dam, Oahe Dam to Big Bend Dam, Big Bend Dam to Fort Randall Dam, Fort Randall Dam to Gavins Point Dam, Gavins Point Dam to Rulo, Nebraska, Rulo to Platte River (St. Joseph Reach), Platte River to Grand River (Kansas City Reach), Grand River to Osage River (Boonville Reach), and Osage River to the mouth of the Missouri River (Hermann Reach).

The alternatives evaluated include management actions with potential to affect river flows, channel form, and river stage. The flood risk management impacts analysis focuses on determining if changes in river and reservoir conditions associated with each of the alternatives could result in an impact to risk of flooding. The impacts to flood risk management were evaluated using three of the planning accounts (NED, RED, and OSE). An interior drainage analysis was conducted on a subset of federal levees to evaluate elevations within the landward side of federal levee areas along the Missouri River.

All action alternatives would result in decreases in flood risk management damages compared to Alternative 1. Alternatives 2 and 4 would result in increases in jobs and labor incomes, whereas Alternatives 5 and 6 would result in decreases and Alternative 3 would be the same as Alternative 1. Impacts from habitat construction actions on flood risk management would be beneficial and limited to areas downstream of the site of habitat construction. Average annual damages at the individual interior drainage sites would range from $116,000 to $403,000 and vary across alternatives. There would be adverse impacts to RED in terms of agricultural damages and no impacts to OSE. For a more detailed summary related to potential impacts to flood risk management and interior drainage, see the environmental consequences summary table below and the full description of flood risk management and interior drainage impacts analysis methods and results in Section 3.12.

Hydropower

The Missouri River hydropower system contains six USACE facilities with a combined nameplate capacity of 2,500 megawatts (MW). Mainstem dams hold water in the river Reservoir System; passing water through the hydropower plants electricity-generating turbines creates a source of low cost, renewable energy. Hydropower generation is dependent on three primary features of the Missouri River System: river flows (dam releases), water elevations, and reservoir System storage. Changes in available water, including daily and hourly river flows and System storage, can impact both the magnitude of normal seasonal generating patterns and reduce the flexibility to meet hourly peaking demands. The value associated with hydropower is based on the accrued cost of the most likely energy source that would replace reductions in hydropower generation. In the Missouri River Basin, peak energy loads (demand) increase in the summer months, when temperatures are highest and farm communities may be pumping water for irrigation or operating grain-drying machinery. These loads are intended to be met by generating the maximum amount of energy during the month of August.

The analysis used the HEC-ResSim Missouri River model that simulates reservoir operations over an 82-year POR, as well as the Missouri River Hydropower Benefits Calculator model to calculate impacts to generation and capacity for each of the six Mainstem dams. The impacts to hydropower were evaluated using three of the planning accounts (NED, RED, and OSE).

Compared to Alternative 1, Alternatives 2, 4, 5, and 6 would result in average annual decreases in generation and hydropower value. Alternative 3 would result in increases in generation and value. Similarly, Alternatives 2, 4, 5, and 6 would result in adverse impacts to RED and OSE. However, Alternative 3 would result in benefits. None of the alternatives would result in significant impacts to hydropower. For a more detailed summary related to potential impacts to hydropower, see the environmental consequences summary table below and the full description of hydropower impacts analysis methods and results in Section 3.13.

Irrigation

Irrigators in 42 counties in Montana, North Dakota, South Dakota, and Nebraska hold permits to use water from the Missouri River for the purpose of agriculture production. This generally includes the area extending from Fort Peck Reservoir to Rulo, Nebraska. A majority (94 percent) of the 816 irrigation intakes along the reservoir System are located in Montana, North Dakota, and South Dakota, while North Dakota has the greatest number of permitted acres of the four states (89,106 acres in 2015). Of 12.5 million acres of cropland harvested in these 42 counties in 2012, approximately 2,266,000 acres, or 18.1 percent, consisted of irrigated cropland. In the upper reaches of the river, the irrigation season lasts approximately from May through September. In the lower river reaches, in Nebraska, the growing season also begins in May but typically extends through October.

It is estimated that the Tribes irrigate 350,000 acres of agricultural lands using water from either the Missouri River or Mainstem reservoirs. Many of the mechanical intakes used for water access by the Tribes are outdated and are prohibitively expensive to repair, and may need to be replaced in order to accommodate changing levels of sediment, high levels of erosion, or reduced access to water.

The environmental consequences analysis for irrigation intakes focuses on changes in river and reservoir conditions associated with each of the alternatives. The environmental consequences for irrigation intakes were evaluated using three of the planning accounts (NED, RED, and OSE). As river flows and reservoir elevations fall below minimum operating requirements, intakes become unavailable to provide water to farm operations (including private farms, Tribes, and commercial operations). This, in turn, can result in changes to net farm income.

Alternatives 2, 4, and 6 would result in long-term adverse impacts to NED and RED in terms of net farm income, employment and annual labor income. Whereas Alternatives 3 and 5 would result in long-term benefits. Any impact to OSE from any of the alternatives would be negligible. None of the alternatives would result in significant impacts. For a more detailed summary related to potential impacts to irrigation, see the environmental consequences summary table below and the full description of irrigation impacts analysis methods and results in Section 3.14.

Navigation

The navigation channel in the Missouri River Mainstem stretches 735 miles, from Sioux City, Iowa to St. Louis, Missouri. This stretch of the river includes a congressionally authorized navigation channel measuring nine feet deep and 300 feet wide. In 2016, there were about 113 active docks and ports along the lower river. The navigation season is limited to periods of time when the river is ice-free. While the length of the flow supported season varies along the river, a full-length season is considered eight months long. Navigation service on the lower river is provided by a combination of water from major tributaries and the release of water from Gavins Point Dam.

The level of navigation service (full, reduced, or minimum) depends on the level of System releases. These full-service flows generally provide the authorized 9-foot navigation channel, and they allow the capability to load barges to an 8.5-foot draft. The level of navigation service provided is determined according to how much water is available in storage on two constant key dates of each year (March 15 and July 1). On March 15, if total System storage is greater than 54.5 MAF, then full service is provided. If System storage is between 31.0 and 49.0 MAF, then minimum service is provided. If System storage is below 31.0 MAF, no navigation service is provided. On July 1, another System storage check occurs. If System storage is 57.0 MAF or greater, full service is provided for the remainder of the navigation season. If the System storage is 50.5 MAF or less, minimum service is provided for the remainder of the navigation season. The navigation impacts analysis focuses on determining if changes in river and reservoir conditions could result in an impact to service level and season length. The impacts to navigation are evaluated using three of the planning accounts (NED, RED, and OSE).

Alternatives 2, 4, 5, and 6 would result in adverse impacts to NED and RED in terms of navigation value, employment, and labor income, compared to alternative 1. Alternative 3 would result in benefits. Any impact to OSE from any of the alternatives would be negligible. None of the alternatives would result in significant impacts to navigation. For a more detailed summary related to potential impacts to navigation, see the environmental consequences summary table below and the full description of navigation impacts analysis methods and results in Section 3.15.

Recreation

The Missouri River corridor between Fort Peck Lake and St. Louis, Missouri, supports a wide range of water, land, and wildlife-related recreational activities and is a popular destination for outdoor enthusiasts, attracting millions of visitors each year. Recreational opportunities, settings, and access to public facilities vary considerably along the river and can be divided into three main geographic locations: Mainstem reservoirs; inter-reservoir river reaches; and the lower river below Gavins Point Dam to the confluence with the Mississippi River. Water-based recreation includes shoreline fishing, boat fishing, power boating, waterskiing, tube towing, jet skiing, tubing, canoeing, kayaking, and swimming. Sport fishing (i.e., fishing for sport or recreation) is a prevalent activity in all locations along the Missouri River and its reservoirs, including cold water and cool water reservoir fishing for salmon and walleye; rainbow trout fishing along the river reaches of Montana; and warm water fishing for bass and catfish. Wetlands, sandbars, and shoreline along the river corridor serve as waterfowl habitat and support opportunities for waterfowl hunting and bird watching. Camping and picnicking are very popular activities at many of the recreation areas during the warmer months. The natural landscapes and viewscapes of the Missouri River reservoirs and inter-reservoir river reaches also attract a large number of sightseers. Visitation to the reservoirs varies from year to year in response to environmental conditions and water elevations, which can affect fishing opportunities and access to shoreline facilities and boat ramps.

The environmental consequences analysis for recreation focuses on how changes in the prevalence of habitat and river and reservoir conditions could affect visitation, recreational opportunities, and the value of the recreational experiences. Environmental consequences were evaluated using three of the planning accounts (NED, RED, and OSE).

Alternatives 2 and 3 would result in increases in NED value compared to Alternative 1, whereas Alternatives 4–6 would result in decreases. Alternatives 2, 4, and 6 could also result in adverse impacts in the upper three reservoirs following spring flow releases. Alternatives 2, 4 and 6 would result in adverse impacts to RED in terms of employment and labor income. Alternatives 3 and 5 would be similar to Alternative 1 with respect to RED impacts. All alternatives would provide benefits to OSE. None of the alternatives would result in significant impacts to recreation. For a more detailed summary related to potential impacts to recreation, see the environmental consequences summary table below and the full description of recreation impacts analysis methods and results in Section 3.16.

Thermal Power

There are 21 thermal power plants (2 nuclear and 19 coal-fired power plants) located along the Missouri River Mainstem or reservoirs. One power plant is located on Lake Sakakawea in North Dakota; six are located on the river below Garrison Dam in North Dakota; and the remaining power plants are located on the river downstream of Sioux City, Iowa. Of the 21 power plants, 9 have units with recirculating cooling systems or cooling ponds, while 12 plants withdraw water from the river for once-through cooling. River flows and associated water surface elevations can affect the amount, timing, frequency, and duration of access to water through the intakes. Low river flows and high river water temperatures can affect plant operational efficiency as well as the ability of the plants to meet their National Pollutant Discharge Elimination System (NPDES) effluent and temperature requirements. The NPDES permit of a thermal power facility includes temperature limits for maximum river water temperature and maximum change in river water temperature within the mixing zone (the volume and flow of the receiving water below the outfall). Critical low flow conditions are used to define mixing zones and the effluent requirements.

The environmental consequences analysis for thermal power plants focuses on changes in river and reservoir conditions associated with each of the alternatives. Environmental consequences were evaluated using three of the planning accounts (NED, RED, and OSE). The analysis focuses on the costs (replacement costs of reduced power generation, capital costs for lost capacity, and variable costs) to power plants and utilities to adapt to changing river and reservoir conditions.

Alternatives 2 and 4–6 would result in adverse impacts to NED while Alternative 3 would result in benefits, compared to Alternative 1. Alternative 2 would also result in adverse impacts to RED, while Alternatives 3–6 would have similar impacts to Alternative 1. Similarly, Alternative 2 would result in adverse impacts to OSE and the other actions alternatives would be similar to Alternative 1. None of the action alternatives have the potential to result in significant impacts, with the exception of Alternative 2, given its adverse impacts to capacity and energy values associate with power generation reductions during low summer flow events. For a more detailed summary related to potential impacts to thermal power, see the environmental consequences summary table below and the full description of thermal power impacts analysis methods and results in Section 3.17.

Water Supply

Water is withdrawn from the Missouri River and Mainstem lakes for multiple purposes including municipal, industrial, and commercial water supply as well as domestic and public uses. Municipal water supply includes Tribal and public supply of water to reservations, residents of cities and towns, and customers of rural water districts and associations. Commercial and industrial use includes self-supplied water for commercial, manufacturing, and other processing uses other than thermal power use. There are an estimated 64 municipal intakes and 35 commercial/industrial water supply intakes on the reservoirs and river reaches of the Missouri River Mainstem. Water supply for municipal and industrial/commercial uses along the Missouri River can be affected by conditions such as river flows and stages, reservoir water surface elevations, river water chemistry including sediment, and channel locations. Changes to these physical components, in turn, lead to changes in water supply conditions including access to water, operation and maintenance, and water treatment requirements.

The water supply impacts analysis focuses on determining if changes in river and reservoir conditions associated with each of the alternatives could result in an impact to water supply intakes. The impacts to water supply are evaluated using three of the planning accounts (NED, RED, and OSE). The analysis focuses on the costs to water supply intake operators to adapt to changing river and reservoir conditions.

Alternatives 4 and 6 could result in adverse NED impacts on water supply intakes, while Alternatives 2, 3, and 5 could result in benefits to water supply intakes. It is unlikely that any of the action alternatives would result in noticeable RED or OSE impacts. However, impacts from habitat construction would result in temporary adverse impacts to water supply intakes. None of the action alternatives are expected to result in significant impacts. For a more detailed summary related to potential impacts to water supply, see the environmental consequences summary table below and the full description of water supply impacts analysis methods and results in Section 3.18.

Wastewater Facilities

Several facilities discharge treated wastewater to the Missouri River and its reservoirs. The facilities include publicly owned treatment works (POTWs) or sewerage facilities and other types of industrial discharges from fertilizer and agricultural chemical companies and meat processing facilities. There are 37 major wastewater facilities discharging to the Missouri River. Most of the discharging facilities are located in the lower river below Gavins Point Dam. These facilities can be affected by river flows, stages, and channel geometry.

Wastewater facilities require a NPDES permit to discharge wastewater into a water body, which specifies the effluent requirements for the relevant parameters for the facilities. The parameters typically regulated by water quality-based effluent limits include ammonia, total residual chlorine, whole effluent toxicity tests, and acute toxicity. Wastewater discharge facility operations can be sensitive to changes in river flows. For facilities with water quality-based effluent limits, low river flows can have a direct relationship with the effluent limits and resulting wastewater treatment requirements. A low-flow criteria analysis was conducted on modeled river flows under the alternatives for locations close to the wastewater discharge facilities. The scope of analysis included facilities in Iowa, Nebraska, Kansas, and Missouri. Facilities in North Dakota and South Dakota were considered but eliminated from further analysis because state water quality regulators indicated that low-flow conditions in the Missouri River do not currently drive effluent limits for facilities in these states. Twenty-nine major wastewater facilities that discharge to the Missouri River were identified in these four lower river states. Each of the wastewater facilities discharging to the Missouri River in Iowa, Nebraska, Kansas, and Missouri were evaluated and facilities were removed from further analysis if they met a set of criteria. The result was five facilities (two in Iowa and three in Missouri) that could potentially be affected under the alternatives.

All alternatives analyzed could result in short-term, adverse impacts to wastewater facilities. None of the alternatives would result in significant impacts. For a more detailed summary related to potential impacts to wastewater facilities, see the environmental consequences summary table below and the full description of wastewater facilities impacts analysis methods and results in Section 3.19.

Tribal Resources

The Tribes of the Missouri River basin are diverse in their histories and their perspectives regarding the Missouri River. There are 29 Tribes located within or having expressed significant interest in their historical connection to the Missouri River Basin. These Tribes maintain current and ancestral ties to the Missouri River and possess cultural, economic, and social interests in the river. Federal agencies planning and implementing recovery and mitigation actions on the river have a trust responsibility to work with Tribes on a government-to-government basis in recognition of Tribal sovereignty. Thirteen of the Tribal reservations (as well as a portion of the Ponca trust land) are adjacent to the river and/or partially within the floodplain. Additional Tribes with ancestral ties to the basin were contacted to determine their consulting interest.

Tribes of the Missouri River Basin have an interest in many of the resources described elsewhere in this document, including agriculture, irrigation, water supply, thermal power, recreation, flood risk management, and fish and wildlife. There are also additional connections to the Missouri River that are unique to Tribal members. Tribal reservations are located in rural areas, where opportunities for fishing, hunting, and trapping can be essential for Tribal members. Through subsistence hunting, fishing, and gathering, some Tribal members use the fish, wildlife, and vegetation of the Missouri River and its floodplain to account for a significant portion of their food supply. Many Tribal members also gather native plants for medicinal and ceremonial uses. The availability of resources that allow for subsistence and/or traditional cultural practices contributes to the cultural identity of many Tribal members.

Many Tribal members use the Missouri River and its floodplain for traditional cultural practices, including traditional Tribal ways of daily life (which may include seeing and interacting with the river throughout the day) and sacred/spiritual values through ceremonies, sun dances, vision quests, and sweat lodges. Protection of cultural resources and preservation of cultural practices are paramount for many Tribal members. These values and ways of life are affected by the physical components of the Missouri River and its floodplain, including its effect on physical resources such as plants, berries, trees, and water. Natural aquatic and floodplain habitats resemble the conditions under which traditional cultural practices were developed. Similarly, the educational opportunities are improved by natural aquatic and floodplain habitats on current and historic Tribal land.

Alternatives are evaluated for their effects on subsistence hunting, fishing, and gathering, as well as traditional cultural practices and educational opportunities. Some of these effects are specific to reservations, while some effects occur on other parts of the Missouri River but are relevant to Tribes nonetheless. The impacts to these specific Tribal interests are evaluated using the OSE account.

Alternatives 3, 5, and 6 could result in both adverse impacts and benefits to Tribal interests related to their use of the floodplain, river, and reservoirs, compared to alternative 1. Alternatives 2 and 4 would provide mainly benefits. None of the alternatives would result in significant impacts to Tribal interests. For a more detailed summary related to potential impacts to Tribal interests, see the environmental consequences summary table below and the full description of Tribal interest impacts analysis methods and results in Section 3.20.

Human Health and Safety

For the purposes of this MRRMP-EIS, human health and safety is characterized in terms of risks to human life, injury, or the introduction or spread of disease as a result of implementing any of the alternatives considered. USACE received public comment that the alternatives being evaluated could result in increases in mosquito-borne diseases. Mosquitoes are serious nuisance pests that affect the health and well-being of humans, companion animals, livestock, and wildlife with their persistent biting behavior. Accordingly, human health and safety could be affected by the implementation of actions associated with this MRRMP-EIS if they result in changed in the availability of mosquito breeding habitat along the Missouri River Mainstem that lead to the potential for increased risk of transmission of disease.

The most common mosquito-transmitted disease within the Missouri River Basin, and in the United States as a whole, is West Nile Virus. Other mosquito-transmitted diseases that are less prevalent but known to occur within the Mainstem Missouri River states include St. Louis encephalitis, western equine encephalitis, and LaCrosse encephalitis. The Zika virus, while not yet known to be transmitted within the Missouri River Basin, represents an emerging threat to human health and safety in states along the Missouri River Mainstem and throughout the country.

The most common nuisance mosquitoes in all of the Mainstem Missouri River states include *Aedes vexans* and several different species within the *Culex* genus. These species use both natural and man-made breeding habitats that include tree holes, standing pools in agricultural fields, roadside ditches, cans, buckets, birdbaths, discarded tires, and clogged gutters. *Aedes vexans* typically lays its eggs on moist soil in vegetated areas just above the waterline in floodplains and pothole depressions. The eggs hatch into larvae when inundated by flooding.

More traditional human health and safety issues associated with the use of construction equipment and other occupational hazards involved in ESH construction and early life stage pallid sturgeon habitat construction are discussed in previous USACE NEPA documents (USACE 2009 and 2012). The analysis of impacts to human health and safety focuses on the potential for increased risk of mosquito-borne diseases as a consequence of implementing any of the alternatives and considers the potential for actions to affect the availability of mosquito breeding habitat, which could in turn affect the transmission of the mosquito-borne arboviruses.

Although each alternative has the potential to create breeding habitat for *Aedes vexans* mosquitoes, they would have no potential to create habitat for common vector mosquito species. As a result, these alternatives would be expected to have no adverse impacts on human health and safety. Therefore, none of the alternatives are expected to result in significant impacts to human health and safety. For a more detailed summary related to potential impacts to human health and safety, see the environmental consequences summary table below and the full description of human health and safety impacts analysis methods and results in Section 3.21.

Environmental Justice

Executive Order 12898, issued in 1994, directs federal agencies to incorporate environmental justice as part of their mission by identifying and addressing the effects of programs, policies, and activities on minority and low-income populations.

The vast majority of environmental justice populations in the project area are located in the states of Nebraska and Missouri, with approximately 150,084 affected residents located in identified environmental justice communities in both states. These populations are largely concentrated within the Omaha-Council Bluffs metropolitan area and the urban areas of Kansas City, St. Louis, St. Joseph, and Jefferson City, Missouri. The environmental justice populations are predominantly located within rural counties on Tribal lands or within larger cities in urbanized areas, having high concentrations of both minority and low-income populations.

The impact analysis for environmental justice focuses on determining if any of the management actions described under the alternatives would have disproportionate impacts on environmental justice populations. The environmental justice assessment evaluated the nature and extent of impacts evaluated under the other resource areas addressed in the EIS (including flood risk management, water supply, thermal power, hydropower, land acquisition, irrigation, recreation, navigation, water quality, and others) and then evaluated whether these impacts would fall disproportionately on potential environmental justice populations that live within the floodplain.

None of the alternatives analyzed are expected to result in disproportionate adverse impacts to potential environmental justice populations. Therefore, none of the impacts are expected to result in significant impacts to environmental justice. For a more detailed summary related to potential impacts to environmental justice, see the environmental consequences summary table below and the full description of environmental justice impacts analysis methods and results in Section 3.22.

Ecosystem Services

Although areas of the Missouri River have been modified, the Missouri River ecosystem provides a steady flow of environmental benefits that sustain life and provide values for humans. These benefits include tangible goods and intangible services that are often referred to as ecosystem services. Ecosystem services provided by the Missouri River support economic activity and contribute to regional quality of life. These environmental goods and services contribute in ways that may or may not be considered in market transactions or economic activity. Some of the notable ecosystem services provided by the Missouri River ecosystem upon which the impact analysis is based include natural resource goods (food, fiber, fuel, construction materials, etc.), water supply, water quality, waste assimilation and nutrient regulation (recycling of nutrients and removal of pollutants by ecological processes), flood attenuation, climate regulation and carbon sequestration, recreation, land values, other cultural services, and non-use values.

Benefits derived from ecosystem services include those from both their direct and indirect uses or through their intrinsic values (not tied to uses). For example, cool-water fisheries along the Missouri River provide direct use benefits to anglers who visit the area, and indirect benefits to people who may enjoy watching fishing programs that take place on the Missouri River at home. Non-use values (passive use values), are values that are not associated with actual use, nor are they directly valued in the market. Non-use values stem from a desire to preserve or improve a resource (e.g., restored ecosystem, endangered species) as a public good, for future use, or for enjoyment by future generations.

With the exception of the ecosystem services of water supply and non-use values, Alternatives 1 and 3–6 are expected to result in similar long-term benefits. However, Alternative 2 would result in greater benefits. Alternative 1 and Alternatives 3–6 are not expected to result in adverse impacts to water supply. Alternative 1 is expected to result in adverse impacts to non-use values as it has a lower likelihood of achieving species objectives, whereas Alternatives 3–6 would meet these objectives and result in benefits to non-use values. None of the alternatives considered would result in significant impacts. For a more detailed summary related to potential impacts to ecosystem services, see the environmental consequences summary table below and the full description of ecosystem services impacts analysis methods and results in Section 3.23.

Mississippi River Impacts

The Middle Mississippi River is the portion of the Mississippi River that lies between the confluence with the Ohio River at Cairo, Illinois and the confluence with the Missouri River at St. Louis, Missouri. The Missouri River contributes almost 50 percent of the flow of the Middle Mississippi River and contributes approximately 75 to 95 percent of the suspended sediment load. The Mississippi River basin has been shaped over time by a variety of actions, including urbanization, agriculture, levee construction, dam construction, and river training structure placement. Many of the changes in the Middle Mississippi River which have led to its current condition are due to improvements made for navigation including river training structure placement and associated sedimentation patterns. The MRRMP-EIS assess the potential impacts of the alternatives on resources in the Middle Mississippi River including the following: biological resources, flood risk management, navigation, water supply and thermal power.

Biological Resources: Similar to the Missouri River, variety of habitat types are found in the Middle Mississippi River, which support a large diversity of macroinvertebrate and fish communities. Side channel habitats in particular are known to support a greater abundance of macrohabitat generalists compared to other macrohabitat types, likely due to the shallow, low-velocity habitat they provide at certain river stages. Side channels provide a well-defined gradient between flowing to non-flowing water, depending on their level of connectivity to the main channel. Flowing side channels, those connected to the main channel, generally have a sand and gravel substrate and support large river aquatic species (suckers, minnows, and darters) tolerant of current and/or turbidity. This diversity of habitat provides important feeding, spawning, nursery, and overwintering habitat for fish, and habitat for other environmentally sensitive macroinvertebrates, fish, and wildlife. As such, side channels are important to the health of the river ecosystem as a whole, and are even more important in the Middle Mississippi River because of the loss of connectivity between the river and floodplain.

Impacts to biological resources in the Middle Mississippi River were analyzed based on stage and flow simulated for each alternative by modeling the alternative operation over the POR (USACE H&H Tech Report 2016). Impacts to three representative side channels were quantitatively analyzed in terms of how changes in stage may potentially alter or impact side channel habitat through altering connectivity with the main channel. It is assumed that changes in stage can alter or impact the condition and accessibility of side channel habitat. It is assumed that the changes in stage modeled under each alternative at the St. Louis gage is representative of the Middle Mississippi River and each of the representative side channels.

Flood Risk Management: Approximately 17,621 people reside in the Middle Mississippi River reach upstream of St. Louis. Residential and nonresidential structures located in areas along the Mississippi River are subject to flood risk. There are 7,091 residential and 883 nonresidential structures identified in the floodplain. Total estimated value of these structures is $5.7 billion. Within the Middle Mississippi River floodplain between St. Louis, Missouri and Thebes, Illinois, a majority of the area is leveed. A total of 13 levee systems comprised of 20 levee districts reduce flood risk for over 310,000 acres of floodplain. Nineteen of these levees were federally constructed. Additional flood risk reduction is provided through flood storage in the many reservoirs in the Missouri, upper Mississippi, and Kaskaskia River basins. This series of levee systems is very robust. Since they were completed, only four of the federal systems have been overtopped and breached, which occurred during the flood of 1993. Analysis of the potential for flood risk management impacts along the Middle Mississippi River downstream of St. Louis was conducted through comparison of change in flood flow frequency curves at St. Louis. Data for this analysis were taken from hydraulic modeling conducted as part of this study. Flow frequency curves were calculated with a procedure matching that used in the Upper Mississippi River Flow Frequency Study (USACE 2004).

Given the more detailed hydrology and hydraulics modeling from the confluence of the Missouri River to St. Louis, the assessment of impacts upstream of St. Louis follows the impacts assessment for the Missouri River more closely than downstream of St. Louis where detailed channel cross-sections were not available. The impacts to flood risk management were evaluated using two of the planning accounts (NED and OSE).

Navigation: Navigation on the Middle Mississippi River includes the transport of commodities using various types of vessels, including towboats and barges. Towboats traveling on the Mississippi River upstream of the Ohio River, which includes the Middle Mississippi River, are usually 160-foot towboats with 3,000 to 5,000 horsepower. Towboats on the lower Mississippi River, from the confluence with the Ohio River to New Orleans, can reach 180 feet in length and have an engine with 8,000 to 10,000 horsepower. The barge sizes are fairly typical in comparison to barges traveling on other rivers, measuring 35 feet wide by 195 feet long. Additionally, the average tow configuration on the lower Mississippi River may consist of 30 to 35 barges. The Middle Mississippi River can handle these larger arrangements for much of its 195 miles, but typically averages around 25 barges per tow. Commodities transported on the Middle Mississippi River include crude petroleum, petroleum produces, grain and grain products, chemicals, aggregates, non-metallic ores and minerals, iron ore and iron and steel products, and coal. These commodities are shipped or received throughout numerous states that touch the Middle Mississippi River. Between 2007 and 2016, the top three receiving states were (1) Louisiana: 56.9 million tons; (2) Illinois: 14.7 million tons; and (3) Tennessee: 5.9 million tons. The top shipping states were (1) Illinois: 49.7 million tons; (2) Missouri: 22.5 million tons; and (3) Louisiana: 14.9 million tons. The navigation impact analysis focuses on determining if changes in river and reservoir conditions on the Missouri River associated with each of the alternatives could affect commodities traveling on the Middle Mississippi River.

Water Supply and Thermal Power: Water is withdrawn from the Mississippi River for multiple purposes including municipal, industrial, and commercial water supply as well as for cooling purposes for power plants. There are four thermal power plants or generating stations and three permanent/fixed water supply intakes located along Middle Mississippi River between St. Louis, Missouri and Cairo, Illinois. As river flows or stages fall below minimum operating requirements, water can no longer be accessed through intakes, resulting in adverse impacts to municipalities, commercial operations, and power plants. This in turn can drive changes in costs to operate intakes and replace power, and possibly affect capital costs to address water access issues. In addition, relatively lower river flows in the summer can affect operational efficiencies of thermal power plants that use once through cooling and affect the ability of the plants to meet NPDES requirements. Power plants can also be affected by river temperature with higher temperatures during the peak summer months causing reduced operating efficiencies and difficulties in meeting NPDES permit requirements. As a result, power plants may need to reduce their power generation.

The impact analysis for water intakes used two approaches to describe the potential impacts to water supply facilities and power plants along the Middle Mississippi River. To assess the impacts of the facilities or plants when river stages fall below critical operating elevations, the river stage thresholds were used from the USACE Master Manual Mississippi River Studies Volume 13 (USACE 1998, Appendix C) for three gage locations (St. Louis, Cape Girardeau, and Chester). The analysis used these critical stages along with the outputs from the HEC-RAS Missouri River models of simulated river flows at the confluence of the Missouri and Mississippi Rivers in St. Louis at river mile 180.

No impacts to river infrastructure and hydrologic processes in the Middle Mississippi River are expected from Alternatives 1, 3, and 5 as flows would be mostly attenuated before they reach the Middle Mississippi River. However, Alternatives 2, 4, and 6 may result in adverse impacts. None of the action alternatives analyzed would result in impacts to biological resources in the Middle Mississippi River compared to Alternative 1. Whereas the action alternatives could result in adverse impacts to flood risk management, compared to Alternative 1. For navigation on the Middle Mississippi River, Alternatives 2 and 4–6 could result in adverse impacts, while Alternative 3 could result in benefits compared to Alternative 1. Alternatives 1, 2, 4, and 6 could result in adverse impacts to water supply and thermal power, while Alternatives 3 and 5 are unlikely to result in impacts. However, none of the alternatives are likely to result in significant impacts. For a more detailed summary related to potential impacts to ecosystem services, see the environmental consequences summary table below and the full description of ecosystem services impacts analysis methods and results in Section 3.24.

Regional Economic Effect of Program Expenditures

Program expenditures were used to evaluate the regional economic benefits of the MRRMP-EIS alternatives. Many types of actions and activities were included in the list of costs, including habitat construction; program management, integration, and coordination; MRRIC; among many others. Detailed costs categories can be found in Appendix F: Missouri River Recovery Management Plan-EIS Alternatives – Cost Estimates. Program costs were grouped based on the time-period in which they are anticipated to be incurred. Two periods were associated with the timing of the costs: the implementation period (year 0 to year 15) and the operations and maintenance period (year 0 to year 50). The costs for each year over 50 years were obtained for each cost category, and annualized using the Fiscal Year 2018 federal interest rate of 2.75 percent and an amortization rate based on the type of cost. USACE staff familiar with implementation of projects under MRRP identified two regions where spending was likely to occur: the upper river, including the states of Montana, North Dakota, and South Dakota; and the lower river, including Iowa, Missouri, Kansas, and Nebraska.

Alternatives 1 and 2 would provide RED benefits in terms of annual jobs and labor income. However, Alternatives 3–6 would result in adverse impacts to RED. For a more detailed summary related to potential impacts to regional economic effect of program expenditures, see the environmental consequences summary table below and the full description of impacts analysis methods and results in Section 3.25.

Summary of Environmental Consequences of Action Alternatives

The potential impacts associated with each of the alternatives were assessed and the findings are discussed in detail in Chapter 3 and further described in a series of technical reports available at www.moriverrecovery.org. Where possible, impacts were assessed quantitatively; however, for some resources a qualitative analysis was necessary.

The following table provides a summary comparison of the environmental consequences of each action alternative compared to Alternative 1—the No Action alternative. The applicable USACE planning account and analysis metrics used for specific resources are included in the table.

Although absolute values provide important context, it is more relevant to decision-makers to consider the estimated differences between each of the action alternatives and Alternative 1. The table shows the differences in the performance of Alternatives 2 to 6 in relation to Alternative 1.

Environmental Consequences of the Action Alternatives Compared to No Action (Alternative 1)

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
River Infrastructure and Hydrologic Processes							
Other	Impacts to hydrology	Spawning cue releases would be small and result in negligible impacts Negligible to small adverse impacts from mechanical ESH construction (upper river) and channel reconfiguration projects (lower river)	Temporary and long-term, small adverse impacts from spawning cue releases; impacts could be large locally Small to large adverse impacts from mechanical ESH construction (upper river) Negligible to small impacts from SWH construction because of localized nature of impacts	No to negligible adverse impacts to hydrology because of the absence of a reoccurring spawning cue and inclusion of spawning cue test release Negligible to small adverse impacts from mechanical ESH construction (upper river) and IRC construction (lower river)	Temporary and long-term, small adverse impacts from spring ESH creation releases Negligible to small adverse impacts from mechanical ESH construction (upper river) and IRC construction (lower river)	Same as Alternative 4, except timing of impacts (fall) from ESH creation releases	Same as Alternative 4, though slightly smaller impacts from spring spawning cue release
Other	Impacts to geomorphology	Existing geomorphological processes and trends would continue	Temporary and long-term, small adverse impacts from spawning cue releases; impacts could be large locally	Temporary, small, adverse impacts from one-time spawning cue test release	Temporary and long-term, small adverse impacts from spring ESH creation release; impacts could be large locally	Same as Alternative 4, except timing of impacts (fall) from ESH creation releases	Same as Alternative 4, though slightly smaller impacts from spring spawning cue release
Other	Impacts to river infrastructure	Changing flows would affect river infrastructure	Long-term, small adverse impacts given the variability in flows and processes	Temporary or long-term, no to negligible adverse impacts as no impact to flow rate or stage	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2
Other	Impacts to groundwater elevation	Changing flows would affect river groundwater levels	Temporary, small adverse impacts from flow releases	No impacts	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Pallid Sturgeon							
EQ	Impacts to pallid sturgeon population	Negligible impacts from habitat construction Possible long-term benefits from SWH construction, although benefits to age-0 sturgeon are uncertain	Temporary, negligible adverse impact from habitat construction Potential benefits from SWH creation, spawning cue release, floodplain connectivity and adaptive management	Temporary, negligible adverse impact from habitat construction Potential long-term benefits from spawning sites, IRC creation, and adaptive management	Same as Alternative 3 Negligible impacts from spring ESH creating releases	Same as Alternative 3 No impacts from fall ESH creating releases	Same as Alternative 3 Potential benefits from spawning cue releases
Piping Plover and Least Tern (numbers reported in absolute values)							
EQ	Likelihood of meeting piping plover sub-objective 1 (geographic distribution)	Assumed to be met if sub-objectives 2, 3, and 4 are met in both regions (north and south)					
EQ	Piping plover sub-objective 2: north (extinction probability) -lower is better	5.7%	1.4%	4.9%	5.0%	4.9%	4.9%
EQ	Piping plover sub-objective 2: south (extinction probability) - lower is better	26.7%	0.68%	5.0%	5.0%	5.1%	5.0%

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
EQ	Piping plover sub-objective 3 (percent of simulated years where median λ ≥ 1) - higher is better	51%	96%	84%	47%	74%	47%
EQ	Piping plover sub-objective 4 (percent of simulated years where median fledge ratio ≥1.14) - higher is better	22%	98%	98%	60%	84%	33%
Fish and Wildlife							
EQ	Habitat quality and availability	Temporary, negligible to small adverse impacts from habitat construction during construction Long-term, large benefits	Temporary, negligible to large adverse impacts from habitat construction Overall change in habitat type would be small Localized, large, adverse impact to reservoir fisheries if reservoir criteria not met as a result of low summer flows and/or spring spawning cue release Long-term, large benefits	Temporary, negligible to small adverse impacts from habitat construction Localized, large, adverse impact to reservoir fisheries if reservoir criteria not met during the potential one-time spring pulse flow test Long-term, negligible to small benefits	Localized, large, adverse impact to reservoir fisheries if reservoir criteria not met as a result of spring ESH creation release Other impacts Same as Alternative 3	Localized, large, adverse impact to reservoir fisheries if reservoir criteria not met as a result of fall ESH creation release Other impacts Same as Alternative 3	Localized, large, adverse impact to reservoir fisheries if reservoir criteria not met as a result of spring spawning cue release Other impacts Same as Alternative 3

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Other Special Status Species – Bald Eagle, Northern Long-Eared Bat, Indiana Bat							
EQ	Habitat quality and availability	Temporary, negligible, adverse impacts from construction activities Long-term benefits from 7,046 acres acquired	Temporary, negligible, adverse impacts from habitat construction Long-term, benefits from 45,716 acres acquired	Temporary, negligible, adverse impacts from habitat construction Long-term benefits from 1,772 acres acquired)	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Water Quality							
EQ	Water quality parameters (e.g., temperature, dissolved oxygen, and nitrogen and phosphorus)	Temporary, negligible, adverse impacts from increased nutrients, pollutants, and water temperature and lower dissolved oxygen levels Temporary, small adverse impacts from increased sediment and turbidity Long-term, negligible, beneficial impacts from reduced nutrients and pollutants	Temporary impacts would be the same as Alternative 1 Long-term, negligible adverse impacts could result from localized areas of increased water temperatures and less dissolved oxygen and negligible to small, beneficial impacts from reduced nutrients and pollutants	Temporary impacts would be the same as Alternative 1 Long-term impacts would be the same as Alternative 2	Temporary, impacts include negligible adverse impacts from increased nutrients, pollutants, and water temperature, and dissolved oxygen alterations, and small, adverse impacts from increased sediment and turbidity Long term negligible, beneficial impacts from reduced nutrients and pollutants	Temporary impacts include negligible adverse impacts from increased nutrients and pollutants, negligible to small adverse impacts from water temperature and dissolved oxygen alterations, and small, adverse impacts from increased sediment and turbidity Long term negligible, beneficial impacts from reduced nutrients and pollutants	Temporary impacts would be the same as Alternative 5 Long-term impacts would be the same as Alternative 5

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Air Quality							
EQ	Air quality parameters (i.e., criteria air pollutants and greenhouse gas emissions)	Localized, temporary, negligible, adverse impacts from habitat construction-related emissions	Localized, temporary negligible adverse impacts would be similar to Alternative 1, but slightly worse as more habitat would be constructed	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Cultural Resources (numbers reported are relative to Alternative 1)							
EQ	Max. No. of Sites Affected (reservoir sites)	1,138	-22	0	+1	0	+1
EQ	Max. No. of Sites Affected (riverine sites)	1,483	-8	0	0	0	-1
EQ	Ave Annual Sites-days (reservoir sites)	55,937	+1,614	-237	+1,707	+879	+2,464
EQ	Ave Annual Sites-days (riverine sites)	16,430	-50	-16	+38	-68	+53
Land Ownership (numbers reported are relative to Alternative 1)							
RED	Regional employment (jobs) -higher is better	-23 jobs	-117 jobs	+16 jobs	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
RED	Regional income -higher is better	-$1,100,000	-$6,200,000	+$843,000	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
RED	Tax revenues -higher is better	-$117,000	-$786,000	+$106,000	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
OSE	Relative impacts to individual and community resiliency, traditional ways of life, and economic vitality	Negligible to small adverse impacts to individual and community resiliency, traditional ways of life, and economic vitality	Negligible to large, adverse impacts depending on the concentration of acquired lands	Negligible adverse impacts	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Commercial Sand / Gravel Dredging							
Other	Changes measured in average annual sedimentation accumulation rate	Negligible measured change in the average annual sediment accumulation rate	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Other	Potential protective measures	Small adverse impacts from SWH construction and potential protective measures	Same as Alternative 1	Small adverse impacts from IRC protective measures	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Flood Risk Management (numbers reported are relative to Alternative 1)							
NED	Ave. $NED/yr damages -lower is better	$30,482,337	-$1,705,203	-$232,725	-$688,044	-$548,536	+$282,851
RED	Ave. regional employment (jobs) -higher is better	Range in reduction in job losses (1–40)	+4	0	+1	+1	-1
RED	Ave. $RED/yr income -higher is better	-$46,000 to -$2,600,000	+$188,000	-$8,000	+$73,000	-$4,000	-$65,000

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
OSE	Population at risk (individuals) -lower is better	592	-26	-4	-5	-14	-5
OSE	Sum of Ft. Randall and Garrison reaches exceedances in POR (days) -lower is better	53	+427	-53	+793	+495	+541
Other	Impacts from habitat construction	Small benefits limited to downstream areas from habitat construction	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Interior Drainage (numbers reported in absolute values)							
NED	Ave. $NED/yr damages at individual sites	$120,000 to $399,000	$114,000 to $387,000	$123,000 to $399,000	$123,000 to $399,000	$124,000 to $398,000	$124,000 to $397,000
RED	Ave. regional employment (qualitative)	Negligible to small adverse impacts	Negligible impact	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2
OSE	Population at risk (qualitative)	No impacts	No impacts	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2
Other	Impacts from habitat construction	No to negligible impacts from habitat construction actions	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Hydropower (numbers reported are relative to Alternative 1)							
NED	Ave. $NED/yr -higher is better	$491,099,000	-$3,099,000	+$203,000	-$3,771,000	-$1,031,000	-$3,209,000

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
RED	Increased Cost to WAPA (Ave. $/yr) -lower is better	+$1,761,000	+$30,000	-$102,000	+$1,156,000	+$356,073	+$792,000
OSE	Ave. change to CO^2 (lb/yr) -lower is better	15,889,805,078	+9,855,094	-10,999,306	+109,769,010	+35,854,585	+76,021,175
Irrigation (numbers reported are relative to Alternative 1)							
NED	Ave. $/yr net farm income -higher is better	$6,800,000	-$83,000	+$15,000	-$69,000	+$44,000	-$115,000
RED	Ave. regional employment (jobs) -higher is better	341	Decrease <1	Increase <1	Decrease <1	Increase <1	Decrease <1
RED	Ave. labor income yr income ($) -higher is better	$13,600,000	-$28,000	+$4,000	-$14,000	+$21,000	-$30,000
OSE	Relative impacts to community well-being, traditional ways of life, and economic vitality	Negligible long-term impacts to community well-being, traditional ways of life, and economic vitality.	Short-term small adverse and long-term negligible impacts to community well-being, traditional ways of life, and economic vitality.	Same as Alternative 2	Same as Alternative 2	Same as Alternative 1	Same as Alternative 2

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Other	Impacts from habitat construction	Temporary, localized, relatively small adverse impacts limited to intakes near habitat construction	Temporary, localized, relatively small adverse impacts limited to intakes near habitat construction, though greater than Alternative 1 given the amount of habitat constructed	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Navigation (numbers reported are relative to Alternative 1)							
NED	Ave. $NED/yr	$7,400,000	-$35,000	+$21,000	-$181,000	-$57,000	-$127,000
RED	Ave. regional employment (jobs) -higher is better	154	0	0	-2	0	-1
RED	Ave. $RED/yr income -higher is better	$8,800,000	-$11,000	+$13,000	-$94,000	-$9,000	-$85,000
OSE	Relative impacts to air quality	Negligible impacts to air quality, traffic congestion, public health and safety, and infrastructure costs in the regional context	Negligible change in air quality, traffic congestion, public health and safety, and infrastructure costs because of the small change air emissions and truck transportation in the region	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Recreation (numbers reported are relative to Alternative 1)							
NED	Ave. $/yr recreation value -higher is better	$102,400,000	+$112,000	+$83,000	-$1,100,000	-$86,000	-$846,000
RED	Ave. employment (jobs) (Mainstem reservoirs) -higher is better	1,512	-3	2	-21	-1	-18
RED	Ave. $RED income (Mainstem reservoirs) -higher is better	$42,400,000	-$108,000	+$70,000	-$585,000	-$29,000	-$511,000
OSE	Relative impacts to individual and community well-being and quality of life	Large benefits associated with considerable recreational opportunities	Relatively higher OSE benefits to recreation	Negligible Changes in OSE Benefits from Alternative 1	Negligible Changes in OSE Benefits from Alternative 1	Negligible Changes in OSE Benefits from Alternative 1	Negligible Changes in OSE Benefits from Alternative 1
Other	Impacts from habitat construction	Temporary, small, adverse impacts from habitat construction Relatively long-term, small benefits	Temporary, small to large adverse impacts from habitat construction Relatively long-term, small to large benefits	Similar to Alternative 1	Similar to Alternative 1	Similar to Alternative 1	Similar to Alternative 1
Thermal Power (numbers reported are relative to Alternative 1)							
NED	Ave. $/yr energy values + capacity value-variable cost. -higher is better	$3,645,386,757	-$59,994,334	+$16,813	-$3,124,916	-$1,006,844	-$1,245,525

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
RED	Variation in power generation (qualitative)	Variations in power generation would range considerably with a worst-case decrease of ~6 million MWh during drought conditions from normal conditions. Alternative 1 management actions (spring pulse) would have a negligible impact	Relatively higher wholesale energy prices, especially during low summer flow events, with the potential for an increase in retail electricity rates over time compared to Alternative 1. Relatively long-term and adverse impacts to spending and regional economic conditions could occur	Negligible change from Alternative 1	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
OSE	Ave. change to CO^2 (lb/yr) -lower is better	167,000,000,000	+15,400,000	-5,800,000	-113,800,000	-18,900,000	-33,900,000
Other	Impacts from habitat construction	Temporary, negligible to small, adverse impacts	Temporary, small to large adverse impacts	Negligible impact	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Water Supply (numbers reported are relative to Alternative 1)							
NED	Ave. $NED/yr -lower is better	$584,000	-$6,000	-$3,600	+$28,000	+$1,200	+$24,800
RED	Change in water utility rates (qualitative)	Intake improvements may result in increases in water rates to customers	Negligible impact	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2
OSE	Change in water supply access (qualitative)	Negligible impact	Short-term small benefits	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Other	Impacts from habitat construction	Temporary, localized, small, adverse impacts to water supply intakes located in reaches where the habitat construction would take place	Temporary, potential for small, adverse impacts from large amount of habitat construction to water supply intakes located in reaches where the habitat construction would take place	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Wastewater							
Other	Pollutant effluent limits	Negligible impacts allowing facilities to continue to operate within existing parameters	Negligible impacts to waste water facilities in most locations. Possible short-term, large, adverse impacts to two wastewater facilities are anticipated, although future investments in treatment technology could reduce impacts to small	Negligible to small adverse impacts	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Tribal Interests							
OSE	Ability of Tribal members to use the floodplain in terms of subsistence hunting, fishing and gathering, traditional cultural practices and educational opportunities	Habitat improvements would continue to provide long term opportunities for subsistence hunting, fishing, and gathering and for traditional practices and educational opportunities.	Overall long-term benefits to subsistence hunting, fishing, and gathering and for traditional practices and educational opportunities from increased habitat improvements compared to Alternative 1.	Small decrease in opportunities for traditional cultural practices; benefits to subsistence gathering. Overall adverse impacts would be small Habitat improvements would continue to provide long term opportunities for subsistence hunting, fishing, and gathering and for traditional practices and educational opportunities, but to a lesser extent than Alternative 1.	Opportunities for traditional cultural practices and education in the upper river would be increased, while similar to Alternative 1 in the lower river. Benefits in the upper river provided to subsistence gathering; other impacts would be similar to Alternative 1	Same as Alternative 3	Small increase in opportunities for traditional cultural practices in the upper river and a decrease in the lower river; benefits to subsistence gathering would occur in the lower river, with decrease in the upper river. Overall adverse impacts would be small. Benefits from continued habitat improvements similar to Alternative 3.
Human Health and Safety							
OSE	Risk of mosquito-borne illness	No potential to create habitat for common vector mosquito species, therefore no adverse impacts on human health and safety	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Environmental Justice							
OSE	Disproportionate impact to EJ populations	Not expected to have disproportionate adverse impacts	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Ecosystem Services							
Ecosystem Services – Natural Resource Goods							
EQ	Change in availability in natural resource goods	Long-term, beneficial impacts to some types of wildlife and aquatic habitats, increasing the prevalence of fish and wildlife for subsistence, recreation, and potentially commercial harvesting. The provision of sediment would continue as a long-term benefit.	Higher long-term benefits to some fish and wildlife. No to negligible changes to commercial fishing. Negligible changes to the provision of sediment.	Negligible impact	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Ecosystem Services – Water Supply							
EQ	Impacts to surface and ground water	No impact	Long-term, negligible to small benefits	Negligible impact	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Ecosystem Services – Water Quality, Waste, Assimilation, Nutrient Regulation							
EQ	Changes in water quality, waste, assimilation, nutrient regulation	Long-term benefits from reduced sediment and turbidity, nutrients, and pollutants Negligible impact to waste assimilation	Long-term, negligible to small benefits on water quality, waste assimilation, and nutrient regulation	Negligible impact	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Ecosystem Services – Water Regulation and Flood Attenuation							
EQ	Change in water regulation and flood attenuation	The creation habitat would result in beneficial impacts to water regulation and flood attenuation through added conveyance that may slightly decrease river stage locally	Higher long-term benefits; may slightly decrease river stage locally	Negligible impact	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Ecosystem Services – Carbon Sequestration and Climate Regulation							
EQ	Level of carbon sequestration	Beneficial impact on carbon sequestration capacities from natural habitat creation and restoration	Relatively higher long-term benefits to carbon sequestration capacities compared to Alternative 1; long-term, negligible benefits to climate regulation	Negligible impact	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Ecosystem Services – Recreation							
EQ	Change in recreation value	Long –term benefits from habitat construction	Long-term, negligible to small benefits	Negligible impact	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Ecosystem Services – Land Values							
EQ	Change in property value	Properties near habitat areas could realize an increase in land and property values resulting in long-term, beneficial impact	Long-term, negligible to small benefits	Negligible impact	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Ecosystem Services – Other Cultural Services							
EQ	Impacts to cultural services	Habitat construction would provide beneficial impacts to other cultural services on the river and its related terrestrial lands	Small benefits	Negligible impact	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Ecosystem Services – Non-Use Values							
EQ	Ability to meet species' objectives	Reduced likelihood of meeting the species objectives, with potential adverse impacts to non-use values	Higher long-term benefits from substantially more habitat creation	Higher long-term benefits, though not as much as Alternative 2	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Middle Mississippi River							
Middle Mississippi River – River Infrastructure and Hydrologic Processes (numbers reported are relative to Alternative 1)							
EQ	Impacts to flow or stage (feet)	Existing hydrologic conditions in the Middle Mississippi River would continue and the spawning cue release pulses would be mostly attenuated by the time they reach the Middle Mississippi River and would not cause impacts	Potential to result in -1 to -2 change in stage; short-term change in July and August	No impacts	Potential to result in +1 to +3 change in stage; long-term, negligible to small adverse impacts	Potential to result in +1 to +3 change in stage, long-term, negligible to small adverse impacts	Potential to result in +2 change in stage, long-term, negligible to small adverse impacts

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Middle Mississippi River – Biological Resources							
EQ	Impact to side channel habitat condition or accessibility (qualitative)	The periods of connection and disconnection of the side channels would be a result of natural cycles rather than caused by management actions	No impact	No impact	No impact	No change to a small benefit in connectivity and flow status	No change to a small benefit in connectivity and flow status
Middle Mississippi River – Flood Risk Management (numbers reported are relative to Alternative 1)							
NED	Ave. $NED/yr damages -lower is better	$13,894,000	-$11,898,000 to +$6,345,000	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2
OSE	Impacts to individual and community safety, health, and well-being (Ave. PAR/yr) -lower is better	196	-3	-1	-3	0	-1
Middle Mississippi River – Navigation (numbers reported are relative to Alternative 1)							
NED	Ave. $NED/yr (costs) -lower is better	$43,800,000	+$13,942	-$14,900	+$153,000	-$7,900	+$197,000

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Middle Mississippi River – Water Intakes							
Other	River stages below threshold (qualitative)	Temporary, negligible to small, adverse impacts from river stages falling below critical thresholds; however, management actions would not contribute to these adverse effects	Temporary, negligible to small adverse impacts from small increase in days below critical threshold	No to negligible adverse impacts	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Program Expenditures (NED reported in absolute values; RED reported in numbers relative to Alternative 1)							
NED	Ave. Annual NED Implementation Costs -lower is better	$74,503,778	$196,956,768	$40,863,033	$36,915,915	$37,909,346	$37,856,127
RED	Long-term, Ave. regional employment (jobs) -higher is better	495	+666	-110	-164	-150	-151
RED	Long-term, Ave. $RED/yr income -higher is better	$28,000,000	+$33,800,000	-$5,900,000	-$8,600,000	-$7,900,000	-$8,000,000

Plan Selection – Preferred Alternative

Alternative 3 has been identified as the **preferred alternative** in this MRRMP-EIS.

In addition to the actions common to Alternatives 3–6 described above (including active adaptive management; vegetation management, predator management, and human restriction measures on ESH; Level 1 and 2 studies; propagation and augmentation; spawning habitat and channel reconfiguration for IRCs), under Alternative 3, USACE would create ESH through mechanical means at an average rate of 332 acres per year in the Garrison, Fort Randall, and Gavins Point river reaches in years where construction is needed. This amount represents the acreage necessary to meet the bird habitat targets after accounting for available ESH resulting from System operations. Alternative 3 would also include the provision for a one-time spawning cue test release from Gavins Point Dam if the results of Level 1 studies during the first 9–10 years do not provide a clear answer on whether a spawning cue is important.

Alternative 3 has a wide range of benefits relative to Alternative 1, including certain benefits to endangered species, reduced program expenditures, and increased performance for most human considerations (HCs). Hydrologically, the effects of Alternative 3 would be very close to those for Alternative 1 but without the specification for a reoccurring spawning cue releases in March and May. Hydrological differences would be reduced flows relative to Alternative 1 in approximately 30 to 50 percent of years in late March and late April/early May, and corresponding increased flows relative to Alternative 1 during one or two weeks in October or November. The differences in magnitude of these flows would be small compared to those associated with the other alternatives. Alternative 3 would have less channel reconfiguration for pallid sturgeon early life stage habitat relative to Alternative 1, and this would have implications on flow routing and assumed stage-discharge relationships at certain locations.

Although Alternative 3 would not be the most efficient alternative from an overall National Economic Development (NED) standpoint, its lack of adverse NED impacts compared to Alternative 1 is a good balance between overall efficiency and impacts to specific NED resources. Although there are uncertainties associated with its effectiveness in meeting the species objectives (in common with all alternatives), Alternative 3 clearly demonstrates it would be the least impactful means of meeting species objectives across the full range of interests. USACE has completed ESA Section 7 consultation with the USFWS on this alternative as the proposed action and received a no jeopardy finding in the BiOp for the least tern, piping plover, and pallid sturgeon. A further description of the rationale for identifying Alternative 3 as the preferred alternative is provided in the MRRMP-EIS, Section 2.9 of Chapter 2.

Implementation of Preferred Alternative under Adaptive Management

USACE would implement the preferred alternative under the Science and Adaptive Management Plan (SAMP) recognizing the remaining uncertainty associated with many of the proposed management actions and with the ecology of the listed species (particularly for the pallid sturgeon). The SAMP is a companion document to the MRRMP-EIS and includes the process and criteria to implement the initial set of actions included in the preferred alternative. NEPA and adaptive management are complementary processes as both emphasize collaboration and working with stakeholders. Adaptive management is consistent with NEPA's goal of informed decision-making and takes the process further in addressing uncertainties and data gaps that may be revealed during implementation of the preferred alternative.

The preferred alternative represents the initial set of actions the agencies believe will accomplish the objectives (avoid a finding of jeopardy to the listed species) and will allow USACE to fulfill its other statutory requirements. The SAMP is designed to guide the implementation process and help meet Endangered Species Act (ESA) requirements while avoiding and/or minimizing impacts to human considerations, which includes the authorized purposes of the Missouri River as well as the many other services afforded by the river system.

The SAMP provides detailed information on the strategy for addressing uncertainties for each species, provides a governance structure for the program, defines the roles and responsibilities of the participants, and describes both how data are managed and how program actions and results will be communicated and reported.

Primary components of the SAMP include the following:

- Monitoring program associated with the management actions and broader river system;
- Research and study activities including those to address hypotheses for which specific management actions have not yet been identified;
- Assessment methods and processes to evaluate the effectiveness of actions implemented under the preferred alternative;
- Decision criteria used to determine if changes to the preferred alternative are necessary;
- Contingency plans; and
- Governance approach to be used in collaboration with stakeholders, states, and Tribes to make decisions.

The preferred alternative includes the initial suite of management actions, research, and monitoring USACE would implement after approval of the Record of Decision (ROD) aimed at achieving objectives for the pallid sturgeon, piping plover, and interior least tern. The initial set of actions were chosen after careful consideration of species needs, remaining critical management uncertainties, anticipated impacts to authorized purposes and other socioeconomic impacts, and existing impediments to implementation of management actions contained within the other alternatives. The SAMP serves as the repository of knowledge related to management hypotheses, associated management actions, and remaining uncertainties. It is possible that in the future, the adaptive management process will conclude that actions which were not part of the preferred alternative may be warranted and feasible.

The ability to incorporate and adjust to new information is a central concept for successful adaptive management; therefore, if these activities lead to an adjustment in the implementation strategy laid out in the preferred alternative, a supplemental NEPA process may be necessary prior to the end of the 15-year period.

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Table of Contents

Appendices

List of Figures

List of Tables

Supporting Documents

(available online at www.moriverrecovery.org)

Science and Adaptive Management Plan

Human Considerations Technical Reports

- Commercial Sand and Gravel Dredging Environmental Consequences Analysis Technical Report
- Irrigation Environmental Consequences Analysis Technical Report
- Land Ownership Environmental Consequences Analysis Technical Report
- Fish and Wildlife Environmental Consequences Analysis Technical Report
- Flood Risk Management Environmental Consequences Analysis Technical Report
- Hydropower Environmental Consequences Analysis Technical Report
- Agriculture and Interior Drainage Environmental Consequences Analysis Technical Report
- Recreation Environmental Consequences Analysis Technical Report
- Thermal Power Environmental Consequences Analysis Technical Report
- Water Supply Environmental Consequences Analysis Technical Report
- Navigation Environmental Consequences Analysis Technical Report
- Cultural Resources Environmental Consequences Analysis Technical Report

Hydrology and Hydraulics Technical Reports

- Climate Change Assessment – Missouri River Basin
- HEC-RAS Water Temperature Models Developed for the Missouri River Recovery Management Plan and Environmental Impact Statement
- Lower Missouri River Sediment Model Calibration Report
- Lower Missouri River Sediment Model MRRP Alternatives
- Mainstem Missouri River Reservoir Simulation Alternatives Technical Report
- Missouri River Mainstem Reservoir Simulation Report
- Missouri River Recovery Program Management Plan Environmental Impact Statement Summary of Hydrologic Engineering Analysis
- Missouri River Recovery Program Management Plan Environmental Impact Statement Existing Conditions Unsteady HEC-RAS Model Calibration Report
- Missouri River Recovery Program Management Plan Environmental Impact Statement HEC-RAS Modeling Alternatives Report
- Missouri River Recovery Management Plan Time Series Data Development for Hydrologic Modeling

Related Documents:

- Biological Opinion: Operation of the Missouri River Mainstem Reservoir System, the Operation and Maintenance of the Bank Stabilization and Navigation Project, the Operation of Kansas River Reservoir System, and the Implementation of the Missouri River Recovery Management Plan
- Notice of Availability
- Scoping Summary Report
- Missouri River Effects Analysis Reports
  - Missouri River Pallid Sturgeon Effects Analysis – Integrative Report
  - Science Information to Support Missouri River Pallid Sturgeon Effects Analysis
  - Development of Conceptual Ecological Models Linking Management of the Missouri River to Population Dynamics of Pallid Sturgeon
  - Development of Working Hypotheses Linking Management of the Missouri River to Population Dynamics of Pallid Sturgeon
  - Conceptual Ecological Models and Hypotheses for Piping Plovers and Interior Least Terns on the Missouri River
  - Science Information to Support Missouri River Piping Plover and Least Tern Effects Analysis
  - Modeling to Support the Development of Habitat Targets for Piping Plovers on the Missouri River
  - Interim Missouri River Effects Analysis Integrated Report: Piping Plovers and Least Terns
  - Models, Data, and Literature to Support Habitat Analyses for the Missouri River Effects Analysis

Acronyms

AIRFA	American Indian Religious Freedom Act
AM	adaptive management
AOP	Annual Operating Plan
BA	biological assessment
BGEPA	Bald and Golden Eagle Protection Act
BiOp	Biological Opinion
BMP	best management practice
BSNP	Missouri River Bank Stabilization and Navigation Project
CAP	Continuing Authority Program
CDC	Centers for Disease Control
CEM	conceptual ecological model
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	cubic feet per second
CPUE	catch per unit effort
CSP	Conservation Stewardship Program
CSAPR	Cross-State Air Pollution Rule
CSRP	Comprehensive Sturgeon Research Project
CWA	Clean Water Act
CWMP	comprehensive fish and wildlife habitat management plan
ECHO	EPA Enforcement and Compliance History Online
EGM	Economic Guidance Memorandum
EIA	Energy Information Administration
EIS	environmental impact statement
EJ	environmental justice
EM	Engineering Manual
EPA	U.S. Environmental Protection Agency
EQ	environmental quality
EQIP	Environmental Quality Incentives Program
ER	Engineering Regulation
ERDC	Engineering Research and Development Center
ESA	Endangered Species Act
ESH	emergent sandbar habitat
EWPP-FPE	Emergency Watershed Protection Program - Floodplain Easements
EWRP	Emergency Wetland Reserve Program
FCA	1944 Flood Control Act
FL	fork length
FR	Federal Register
FWCA	Fish and Wildlife Coordination Act
FY	fiscal year
gpd	gallons per day
H&H	hydrologic and hydraulic
HBC	hydropower benefits calculator

HC	human considerations
HEC	Hydrologic Engineering Center
HEC-EFM	Hydrologic Engineering Center – Ecosystem Functions Model
HEC-FIA	Hydrologic Engineering Center – Flood Impact Analysis
HEC-IFH	Hydrologic Engineering Center – Interior Flood Hydrology
HEC-NSM	Hydrologic Engineering Center – Nutrient Simulation Modules
HEC-RAS	Hydrologic Engineering Center – River Analysis System
HEC-ResSim	Hydrologic Engineering Center – Reservoir Simulation
IRC	interception and rearing complex
ISAP	Independent Science Advisory Panel
ISETR	Independent Socio-Economic Technical Review
kcfs	thousands of cubic feet per second
km	kilometers
kWh	kilowatt hours
m/s	meters per second
MAF	million acre-feet
Master Manual	Missouri River Basin Mainstem Reservoir System Master Water Control Manual
MATS	Mercury and Air Toxics Standards
MBTA	Migratory Bird Treaty Act
mg/L	milligram per liter
MISO	Midcontinent Independent System Operator
MRLS	Missouri River Levee System
MRO	Midwest Reliability Organization
MRRIC	Missouri River Recovery Implementation Committee
MRRMP-EIS	Missouri River Recovery Management Plan and Environmental Impact Statement
MRRP	Missouri River Recovery Program
Mt/yr	metric tons per year
MW	megawatt
MWh	megawatt-hour
NAAQS	national ambient air quality standards
NAGPRA	Native American Graves Protection and Repatriation Act
NASS	National Agricultural Statistics Service
NED	National Economic Development
NEPA	National Environmental Policy Act
NERC	North American Electric Reliability Corporation
NHPA	National Historic Preservation Act of 1966
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NSI	National Structure Inventory
NSM	Nutrient Simulation Modules
NTU	Nephelometric Turbidity Units
NWR	National Wildlife Refuge

OMBIL	Operation and Maintenance Business Information Link
OMRR&R	operation, maintenance, repair, replacement, and rehabilitation
ORV	Outstandingly Remarkable Value
OSE	other social effects
PA	Programmatic Agreement
P.L.	Public Law
PAD-US	Protected Areas Database of the United States
PAR	population at risk
PCB	polychlorinated biphenyl
PDT	project delivery team
PEIS	Programmatic Environmental Impact Statement
PILT	payments in lieu of taxes
POR	period of record
POTW	publicly owned treatment works
PrOACT	Problem Definition, Objectives, Alternatives, Consequences, and Tradeoffs
PSCAP	Pallid Sturgeon Conservation Augmentation Program
PSPAP	Pallid Sturgeon Population Assessment Project
R, R, & R	repair, replacement, and rehabilitation
RECONS	Regional Economic System
RED	Regional Economic Development
ResSim	Reservoir System Simulation
RM	river mile
ROD	record of decision
RPA	reasonable and prudent alternative
RPM	reasonable and prudent measure
RTO	Regional Transmission Organization
SAMP	Science and Adaptive Management Plan
SCC	social cost of carbon
SEIS	supplemental environmental impact statement
SHPO	State Historic Preservation Officer
SPP	Southwest Power Pool
SWH	shallow water habitat
System	Missouri River Mainstem Reservoir System
TCM	travel cost method
TCP	traditional cultural property
THPO	Tribal Historic Preservation Officer
UDV	unit day value
USACE	U.S. Army Corps of Engineers
USC	U.S. Code
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WAPA	Western Area Power Administration

WHIP	Wildlife Habitat Incentive Program
WRDA	Water Resources Development Act
WRP	Wetland Reserve Program

Chapter 1 Purpose and Need

1.1 Introduction

The Kansas City and Omaha Districts of the U.S. Army Corps of Engineers (USACE), in cooperation with the U.S. Fish and Wildlife Service (USFWS), have developed this Missouri River Recovery Management Plan and Environmental Impact Statement (MRRMP-EIS or Management Plan). This document is a programmatic assessment of major federal actions necessary to avoid a finding of jeopardy to the pallid sturgeon (*Scaphirhynchus albus*), interior least tern (*Sterna antillarum athalassos*), and Northern Great Plains piping plover (*Charadrius melodus*) caused by operation of the Missouri River Mainstem and Kansas River Reservoir System and operation and maintenance of the Missouri River Bank Stabilization and Navigation Project (BSNP) in accordance with the Endangered Species Act (ESA) of 1973, as amended. This programmatic document also assesses the Missouri River BSNP fish and wildlife mitigation plan described in the 2003 Record of Decision (ROD) and authorized by the Water Resources Development Act (WRDA) of 1986, 1999, and 2007 as it relates to endangered species. A programmatic approach to National Environmental Policy Act (NEPA) assessment has the value of setting out the broad views of environmental impacts and benefits for groups of related actions which can later be referenced when making site or project specific decisions (CEQ 2014a). A programmatic NEPA analysis allows an agency to subsequently tier to this analysis, and assess narrower, site- or proposal-specific issues. This avoids repetitive broad-level analyses in subsequent tiered NEPA documents and provides a more comprehensive picture of the consequences of multiple proposed actions. The alternatives evaluated in this MRRMP-EIS include actions that could be implemented immediately upon signing a ROD as well as actions that may require additional site- or proposal-specific NEPA assessment prior to later implementation.

The pallid sturgeon, interior least tern, and Northern Great Plains piping plover are found in and along the Missouri River (Figure 1-1). The pallid sturgeon is a large, long-lived benthic (i.e., bottom-dwelling) fish that inhabits the turbid, fast-flowing rivers of the Missouri and Mississippi River basins. The interior least tern and piping plover are migratory birds that occur on the Missouri River during the breeding season and nest on emergent sandbar habitat (ESH).

Figure 1-1. The Interior Least Tern (left), Pallid Sturgeon (top right), and Piping Plover (bottom right): Federally Listed Species Found along the Missouri River

Declines in the populations of these species led to USFWS listing of the interior least tern as endangered in 1985, the Northern Great Plains piping plover as threatened in 1985, and the pallid sturgeon as endangered in 1990 under the ESA. Formal ESA Section 7 consultation on USACE operation of the Missouri River Mainstem and Kansas River Reservoir System and operation and maintenance of the Missouri River BSNP resulted in the 2003 Amended Biological Opinion (BiOp), which included a jeopardy opinion for pallid sturgeon and a non-jeopardy opinion for interior least tern and piping plover. The 2003 Amended BiOp provided a reasonable and prudent alternative (RPA) to avoid jeopardy, and also included an Incidental Take Statement identifying anticipated take that would occur after implementation of the RPA, reasonable and prudent measures (RPMs) to minimize the take, and terms and conditions to implement the RPMs. USACE has been implementing actions to comply with the 2003 Amended BiOp as part of the Missouri River Recovery Program (MRRP).

This chapter describes the purpose and need for the plan, the objectives, and scope of the MRRMP-EIS, followed by relevant background information on the Missouri River Mainstem Reservoir System (System), Kansas Reservoir System, the BSNP, past ESA consultation associated with the System and BSNP, the BSNP mitigation program, the MRRP, and other information relevant to understanding the proposed action described in this MRRMP-EIS.

1.2 Purpose of the Plan

Purpose defines what the lead agency, in collaboration with cooperators, intends to fulfill by taking action. The purpose should be characterized broadly enough to allow consideration of all reasonable alternatives.

*The **purpose** of this MRRMP-EIS is to develop a suite of actions that meets ESA responsibilities for the piping plover, the interior least tern, and the pallid sturgeon. Authorities used to meet this purpose may include existing USACE authorities related to Missouri River System operations for listed species and acquisition and development of land needed for creation of habitat for listed species provided by Section 601(a) of WRDA 1986, as modified by Section 334(a) of WRDA 1999, and further modified by Section 3176 of WRDA 2007 although alternatives formulation was not limited to these authorities.*

The purpose of this MRRMP-EIS is to develop a suite of actions that meets USACE ESA responsibilities for the pallid sturgeon, piping plover, and interior least tern. Authorities used to meet this purpose may include existing USACE authorities related to Missouri River System operations for listed species and acquisition and development of land needed for creation of habitat for listed species provided in Section 601(a) of WRDA 1986, as modified by Section 334(a) of WRDA 1999, and further modified by Section 3176 of WRDA 2007 although alternatives formulation was not limited to these authorities.

This MRRMP-EIS focuses primarily on requirements found in Section 7 of the ESA. Section 7(a)(1) indicates that all federal agencies shall use their authorities in furtherance of the ESA. It further directs agencies to carry out their programs for the conservation of endangered species and threatened species. This MRRMP-EIS considers specific, short- and long-term management actions for the benefit of the listed species. The results of the plan will contribute directly to furthering the purposes of the ESA. Although Section 7(a)(1) applies to ESA-listed species, actions identified to meet the purpose of this plan could also benefit other native species and will provide some mitigation for the loss of habitat of other native species. Conservation strategies and measures relating to USACE authorities that could be used to benefit listed species are described in the 7(a)(1) Plan which is Appendix C of the Biological Assessment (BA) accompanying this EIS.

Section 7(a)(2) requires federal agencies to ensure that their actions are not likely to jeopardize the continued existence of any threatened or endangered species or result in the destruction or adverse modification of designated critical habitat. The act requires consultation with USFWS in the event that an agency's action may affect a listed species. Through this consultation the agency determines if the actions may result in an adverse effect and if so requests formal consultation and the issuance of a BiOp and associated Incidental Take Statement. Through the consultation process, USFWS must determine whether the effects of the actions could jeopardize the continued existence of the listed species or result in the destruction or adverse modification of designated critical habitat.

The species objectives described in Section 1.4 further describe the intended purpose of this Management Plan.

1.3 Need for the Plan

The ESA requires that operation and maintenance of the System and the BSNP do not jeopardize the continued existence of endangered species or result in the destruction or adverse modification of designated critical habitat. Alteration of the ecosystem and loss of aquatic and terrestrial habitats due to USACE operation of the System and operation and maintenance of the BSNP have contributed to the ESA listing of the pallid sturgeon, piping plover, and interior least tern. Compliance with the ESA is required to continue to operate the System and operate and maintain the BSNP. Since the issuance of the 2003 Amended BiOp and subsequent consultation activities, additional information has become available that has resulted in the need to assess the effectiveness of BiOp compliance activities and develop this Management Plan. The 2003 Amended BiOp provides RPA elements with prescriptive management actions to avoid jeopardy to the pallid sturgeon, interior least tern, and piping plover. USACE has diligently dedicated resources to implementing most aspects of the RPA since 2003; however, significant uncertainty remains regarding the effectiveness of certain actions (NRC 2011; Doyle et al. 2011). Doyle et al. (2011) identified the need for the MRRP to incorporate new scientific information that has become available since the issuance of the 2003 Amended BiOp.

The need for developing the MRRMP is demonstrated by the following:

- Since the 2000 BiOp and 2003 Amended BiOp were published, a substantial amount of research has generated new knowledge regarding pallid sturgeon (Figure 1-2; Jacobson et al. 2016b). For example, the 2003 Amended BiOp hypothesized a lack of shallow water habitat (SWH) was limiting recruitment of pallid sturgeon; however, recent studies have shown age-0 *Scaphirhynchus* sturgeon are captured at a variety of depths with the highest captures often occurring at depths exceeding the SWH metric (Phelps et al. 2010; Ridenour et al. 2011; Gosch et al. 2015; Gemeinhardt et al. 2016; Love et al. 2017). While these studies reported the depths and velocities observed at the location of capture of age-0 *Scaphirhynchus* sturgeon, Gosch et al. (2017) examined the influence of depth at a larger spatial scale than capture locations. Gosch et al. (2017) concluded that the prevalence of water <1.5 m had little effect on catch rates. SWH has also been hypothesized to provide food for age-0 pallid sturgeon; however, Doyle et al. (2011) concluded "There is no evidence that nutrients, invertebrates, or forage fish in the lower Missouri River will increase in response to the managed spring pulse and SWH and there is no evidence to support the assertion that food is limiting, thus preventing the recovery for the pallid sturgeon…" Similarly, Jacobson et al. (2016b) concluded "the continued growth, recruitment, and survival of shovelnose sturgeon, which are thought to share dietary requirements with pallid sturgeon at this life stage, argue against food as a limiting factor." Additional information regarding age-0 pallid sturgeon (i.e., a lack of interstitial hiding, necessary drift distance, etc.) has also accrued since 2003.

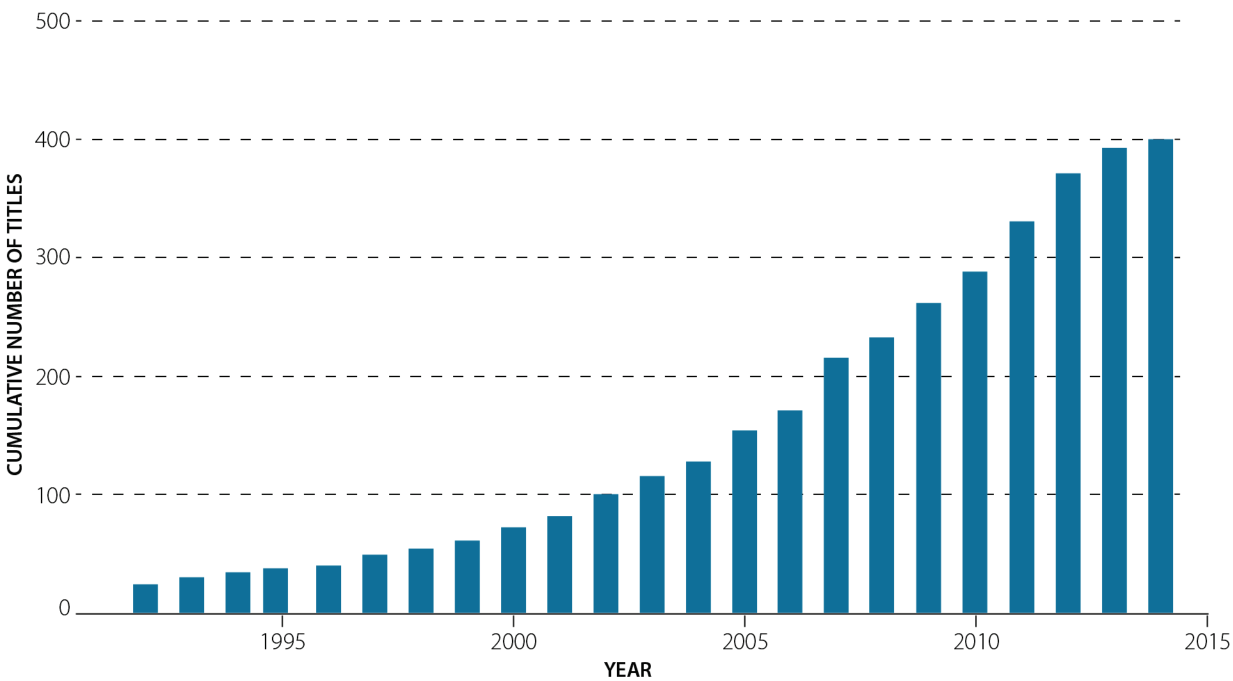

Figure 1-2. Cumulative Number of Scientific Publications on Pallid Sturgeon Since 1990

- In 2011, the Missouri River Recovery Implementation Committee (MRRIC), USACE, and USFWS established the Independent Science Advisory Panel (ISAP). This panel is charged with providing independent science review, input, and advice on technical aspects of the MRRP when requested. The first topic charged to ISAP was Missouri River spring pulse management. The final ISAP report, published in November 2011, concluded "Given that the proposed spring pulse management action has not been implemented in all years, and shovelnose sturgeon and pallid sturgeon exhibited evidence of having spawned in all years studied, the ISAP concludes that the spring pulse management action, as currently designed and implemented, appears to be unnecessary to serve as a cue for spawning in pallid sturgeon" (Doyle et al. 2011). ISAP further stated "Pallid sturgeon have spawned without intentional pulsed flow releases from Gavins Point Dam (DeLonay et al. 2009), but the importance of flow variability due to other sources (such as tributaries) is unknown" and concluded "There is no evidence that managed spring pulses are necessary to provide cues for pallid sturgeon spawning" (Doyle et al. 2011). In addition, ISAP concluded that "There is no evidence that managed spring pulses as implemented result in floodplain-channel connectivity; There is no evidence that nutrients, invertebrates, or forage fish in the lower Missouri River will increase in response to the managed spring pulse and SWH; and There is no evidence to support the assertion that food is limiting, thus preventing the recovery for the pallid sturgeon and least tern." With regard to the purposes of the spring pulse to scour pallid sturgeon spawning areas and condition new and existing sandbar habitat ISAP concluded "There is no evidence that scoured sediment availability is a limiting factor for pallid sturgeon spawning" and "Managed spring pulses have not been successful in scouring emergent bars or reducing the vegetation cover that is necessary to provide suitable nest sites for least terns and piping plovers."

- The final ISAP report also recommended developing a new Science and Adaptive Management Plan (SAMP) that would anticipate implementation of combined flow management actions and mechanical habitat construction. Under ISAP's recommendations, this new plan would be used to guide future management actions, monitoring, research, and assessment. ISAP also recommended basing the new SAMP on an effects analysis (Doyle et al. 2011), which would precede the development of the plan and incorporate new knowledge about the species accrued since the 2003 Amended BiOp (USFWS 2003). Based on this report, MRRIC recommended seven actions to USACE and USFWS in August 2012.
    1. An effects analysis should be developed that incorporates new knowledge accrued since the 2003 Amended BiOp. As part of this analysis:
        - The effects of the Missouri and Kansas River operations on the listed species should be reviewed and analyzed in the context of other stressors on the listed species;
        - The quantitative effects of potential management actions on the listed species should be documented to the extent possible; and
        - These potential management actions should be incorporated into the conceptual ecological models (CEMs).
    2. CEMs should be developed for each of the three listed species and these models should articulate the effects of stressors and mitigative actions (including, but not limited to, flow management, habitat restoration actions, and artificial propagation) on species performance.
    3. Other managed flow programs and adaptive management (AM) plans should be evaluated as guidance in development of the CEMs and AM strategy.
    4. An overarching AM strategy should be developed that anticipates implementation of combined flow management actions and mechanical habitat construction. This strategy should be used to guide future management actions, monitoring, research, and assessment activities within the context of regulatory and legal constraints.
    5. Monitoring programs along the Missouri River should be reviewed to determine whether hypothesized outcomes are occurring and the extent to which the outcomes are attributable to specific management actions.
    6. The agencies should identify decision criteria (trigger points) that will lead to continuing a management action or selecting a different management action. A formal process should be designed and implemented to regularly compare incoming monitoring results with the decision criteria.
    7. Aspects of how the entire hydrograph influences the three listed species should be evaluated when assessing the range of potential management actions.
- An effects analysis (Murphy and Weiland 2011) was initiated in 2013 to synthesize new scientific information specific to these three species and concluded that considerable uncertainty remains regarding the type and extent of management actions ultimately

needed to lead to population growth for each of the three species. The process for developing the effects analysis was supported by the lead agencies, MRRIC, and ISAP as the mechanism for synthesizing and conveying the best available science. The process was reviewed regularly and closely followed. The resulting products, developed transparently by independent experts with input from USFWS, MRRIC, and other agency staff, underwent substantial independent review. The emergence of this new information created a need for its evaluation and integration into USACE management actions on the Missouri River for the listed species. The primary and relevant products of the effects analysis include:

  - CEMs (Jacobson et al. 2016a; Buenau et al. 2016a).
  - Synthesis of existing models and scientific data/information reflecting the state of science for the species and their habitats (Jacobson et al. 2016b; Buenau et al. 2015).
  - Hypotheses addressing critical uncertainties (Jacobson et al. 2016a; Buenau et al. 2016a).
  - Models of reservoir operations and hydraulic conditions, habitat availability (Jacobson et al. 2016b), and species demographics (Jacobson et al. 2016b; Buenau et al. 2016b).
  - A variety of other papers, reports, and methodologies supporting the development of species targets, management actions and alternatives, and the SAMP.

- A recent revision of the pallid sturgeon recovery plan notes that the status of pallid sturgeon has improved since listing under the ESA and it is currently stable as a result of artificial propagation and stocking efforts (Figure 1-2 in USFWS 2014). If stocking were to cease however, pallid sturgeon would face local extirpation in several reaches of the Missouri River (USFWS 2014). There continues to be no evidence of successful reproduction or recruitment of pallid sturgeon in the Missouri River upstream of Gavins Point Dam. As of 2014, USACE had implemented 2,226 construction actions for the purposes of providing SWH on the lower Missouri River. This included construction of 39 side-channel chutes and 14 backwaters. The remaining construction actions were channel modifications that included dike notching, chevron construction, dike extensions, dike lowering, revetment chutes, and channel widening (USACE 2015f). USACE estimated that as of 2014, approximately 11,325 acres of SWH were available from Ponca, Nebraska, to the mouth (USACE 2015f). Although pallid sturgeon spawning has been regularly documented within the lower Missouri River, with some evidence of successful reproduction, evidence of recruitment to age-1 is limited and currently unquantifiable.
- USACE has constructed 872 acres of ESH from 2004 to 2011, and treated over 5,900 acres of sandbars through vegetation management practices since 2004. However, monitoring of the piping plover population and numerical modeling of its chance of persistence suggests a risk of local extirpation on the Missouri River within 50 years under the existing management approach.
- Currently, one of the criteria necessary for the interior least tern to be removed from the endangered species list as stated in the 1990 Recovery Plan is a range-wide population of at least 7,000 individuals (USFWS 1990). According to the 2013 5-year review (USFWS 2013), the population has not only reached 7,000 individuals but has exceeded this number for the years 1994–2012, resulting in a recommendation of delisting for interior least terns. However, most of the population increases that achieved the

population criteria are located within lower Mississippi River populations, not the Missouri River. The interior least tern population within two of three Missouri River reaches have been stable compared to the criteria set in the 1990 Recovery Plan. As part of the interior least tern delisting process, under the conservation mandate of Section 7(a)1 of the ESA, there are efforts underway to develop conservation plans throughout the interior least tern population range. Section 7(a)1 of the ESA requires federal agencies to use their authorities to develop and carry out conservation programs for listed species. USACE Mississippi Valley Division on the lower Mississippi River, the Louisville District for the lower Ohio River, and the Southwestern Division for the Red and Arkansas rivers are developing 7(a)1 plans with post-delisting management commitments. After USACE management strategies are drafted, there will be a Section 7(a)1 consultation with the relevant USFWS office. When these management plans are finalized, nearly all of the interior least tern population will be covered under post-delisting management commitments. USFWS is anticipating that the MRRMP-EIS would serve as the conservation plan that would meet the interior least tern delisting requirement for the Missouri River. USFWS has stated to USACE in a Planning Aid Letter dated November 13, 2015, that managing for sufficient nesting habitat to sustain a piping plover population in the Missouri River would also provide sufficient nesting habitat for the interior least tern in the Missouri River. Piping plovers and interior least terns are sympatric nesters, often using the same breeding sites throughout the Missouri River basin. Development of management actions in this MRRMP-EIS need to demonstrate benefits to the interior least tern to comply with the conservation plan requirements of Section 7(a)1.

Fundamental uncertainties remain about the limiting factors affecting the pallid sturgeon, piping plover, and interior least tern and the associated potential management actions. Due to the uncertainty associated with potential pallid sturgeon limiting factors, there is a demonstrated need to develop a management plan comprised of actions informed by best available science implemented within an adaptive framework. Development of a management plan that balances the substantial uncertainty regarding the beneficial effect of actions with the need to implement actions for a meaningful biological response is difficult and requires a robust adaptive management plan.

1.4 Plan Objectives

USFWS provided fundamental objectives, sub-objectives, targets, and performance metrics for each of the three listed species pursuant to their responsibilities for administering the ESA, and special expertise as a cooperating agency on this MRRMP-EIS. These objectives were informed by the effects analysis products. Achieving these objectives would meet the purpose and fulfill the need for the plan.

1.4.1 Pallid Sturgeon Objectives

Pallid Sturgeon Fundamental Objective: Avoid jeopardizing the continued existence of the pallid sturgeon from USACE actions on the Missouri River.

Although attaining a self-sustaining population is the desired outcome of the Revised Pallid Sturgeon Recovery Plan (USFWS 2014b), it could take decades for such an objective to be meaningful. If natural recruitment were achieved in 10 years, an additional 20 to 30 years would be needed before meaningful assessments of the self-sustaining population objective could be conducted. Therefore, USFWS also proposed two sub-objectives to (1) provide direction in the short term; (2) provide objectives meaningful for adaptive management; and (3) focus efforts on the desired short-term outcomes while keeping the fundamental objective in mind. The two sub-objectives provide guidance for the actions as well as monitoring and research required to support the fundamental objective over the longer term.

Pallid Sturgeon Sub-Objective 1: Increase pallid sturgeon recruitment to age 1.

Metrics: The primary metric is catch rates of age-0 and age-1 pallid sturgeon; secondary metrics include model-based estimates of abundance of age-0 and age-1 pallid sturgeon, and the survival of hatchery and naturally reproducing fish to age-1.

Target: The short-term target is to demonstrate measurable recruitment to age-1, and hopefully increasing levels of recruitment over time. Recruitment is emphasized in sub-objective 1 since wild-spawned young-of-year or juvenile pallid sturgeon have not been captured in the upper Missouri River upstream of Lake Sakakawea, and have been captured only rarely in the lower Missouri River (Jacobson et al. 2016b). Until 2015, there had been no documented captures of genetically identified, wild-spawned pallid sturgeon free embryos, larvae, or young-of-year in the lower river (USFWS 2014b). Recent data indicate that limited recruitment is happening in the lower Missouri River, but it is unknown if it is sufficient to lead to population growth.

The long-term target for recruitment (i.e., necessary levels and frequency of recruitment over time) will be informed by the ongoing science efforts (Jacobson et al. 2016a) and the collaborative population model described in Appendix D of the SAMP, following the necessary monitoring, model validation, and supporting research. Defining the long-term target is not critical in the near term as the immediate priority is to establish measurable recruitment. Possible targets could include a modeled egg to age-1 survival rate sufficient to result in growth and sustainable population size.

Pallid Sturgeon Sub-Objective 2: Maintain or increase numbers of pallid sturgeon as an interim measure until sufficient and sustained natural recruitment occurs.

Metrics: Population estimates for pallid sturgeon for all age classes, particularly for ages 2 to 3 to assess recent trends in recruitment; catch rates of all pallid sturgeon by size class (to maintain legacy data). Age classes will be estimated as an output metric of the population model that will be validated through recaptures of tagged fish. There are challenges in quantifying a population size for 2- to 3-year-old pallid sturgeon due to considerable length overlap of 2- to 5-year-old fish. Further work is required to refine population metrics, which may include estimating a population size for a subset of the length frequency distribution.

Target: Possible targets could include (1) positive population growth rates (i.e., lambda (λ) > 1) of pallid sturgeon age 2 and older; (2) estimated survival rates of all size/age classes sufficient to provide a stable population of pallid sturgeon age 2 and older; and (3) acceptable probabilities of persistence and recovery over a 50- to 100-year time frame (using population models).

1.4.2 Piping Plover Objectives

The fundamental objectives for the piping plover and interior least tern identified in this section are consistent with USFWS current established recovery goals for the piping plover and interior least tern; however, they were developed specifically to avoid a finding of jeopardy to the species due to USACE operation and maintenance of the System. The fundamental objectives and subsequent sub-objectives described later in this section are USFWS desired outcomes from USACE actions to be evaluated as part of the MRRMP-EIS. The methods used to derive targets and their application are discussed further in Section 3 of the SAMP. USFWS believes that if the targets for the sub-objectives described are attained, it will result in the achievement of the stated fundamental objectives. USFWS anticipates regular assessment and refinement of the sub-objectives, means objectives, performance metrics, and targets through the AM process.

Population resiliency is primarily determined by habitat availability rather than an initial population size (Buenau et al. 2015). As a result, and as indicated in the targets, USFWS proposed using acres of ESH as a target to ensure a resilient population of birds on the Missouri River. Acres of ESH are calculated using the ESH models for each reach and are confirmed annually using remotely sensed imagery and the Hydrologic Engineering Center – River Analysis System (HEC-RAS) models. Sandbar acreage is expressed in two ways:

- Standardized ESH: The sandbar area meeting definitions for ESH that is above a reference plane corresponding to the water surface profile at 31.6 kcfs in the reach below Gavins Point Dam, 30.5 kcfs in the reach between Fort Randall Dam, and 23.9 kcfs in the reach below Garrison Dam. Estimating ESH acreage relative to a consistent reference plane permits tracking of changes in overall sandbar area independent of variable flow levels.
- Available ESH: The sandbar area meeting definitions for ESH that is above the maximum observed water surface during July of each year. It is calculated using stage/area relations for sandbars determined from field measurements and applied to acreages obtained from remotely sensed imagery for that period. Available ESH is an estimate of usable habitat for the birds during the nesting season in each year, and may be more or less than standardized ESH depending on flow releases that year relative to the standardized reference flows.

Geographic distribution of the Missouri River piping plover population (sub-population of the Northern Great Plains population) is described by two distinct geographic regions:

- Northern Rivers Region: the Missouri River from Fort Peck Lake, Montana to Fort Randall Dam, South Dakota.
- Southern Rivers Region: the Missouri River from Fort Randall Dam, South Dakota to Ponca, Nebraska.

Piping Plover Fundamental Objective: Avoid jeopardizing the continued existence of the piping plover due to USACE actions on the Missouri River.

Sub-Objective 1 (Distribution): Maintain a geographic distribution of piping plovers in the river and reservoirs in which they currently occur in both the Northern and Southern River Regions.

Means Objective: Meet sub-objectives 2, 3, and 4 in both the Northern and Southern Regions.

Sub-Objective 2 (Population): Maintain a population of Missouri River piping plovers with a modeled 95 percent probability that at least 50 individuals will persist for at least 50 years in both the Northern and Southern Regions.

Means Objective (ESH): Provide sufficient ESH (in-channel riverine habitat) on the Missouri River to meet the persistence target.

Metric: Number of standardized and available ESH acres measured annually.

Target: Targets are shown in Table 1-1.

Timeframe: Median standardized ESH targets (450 acres in the Northern Region; 1,180 acres in the Southern Region) must be met for 3 out of 4 years. Median available acres must be met or exceeded for the specified percent of years over a running 12-year interval.

Table 1-1. Piping Plover Targets for Sub-Objective 2

		Acres of Emergent Sandbar Habitat					
		Northern Region			Southern Region		
		2.5 percentile	Median	97.5 percentile	2.5 percentile	Median	97.5 percentile
Standardized ESH Acres		190	450	2,160	330	1,180	4,720
Available ESH Acres Exceeded for Percentage of Years	**75%**	170	270	555	300	430	720
	50%	420	680	1,295	500	740	1,550
	25%	960	1,920	2,670	750	1,410	3,075
	10%	1,965	3,000	5,165	1,125	2,240	4,945

Sub-Objective 3 (Population Dynamics): Maintain a stable or increasing long-term trend in population size in both regions.

Metric: Population growth rate (lambda; λ): the ratio of population size *N* between the current year and previous year (N_t/N_{t-1}); calculated annually.

Target: $\lambda \geq 1$ (a growth rate greater than or equal to 1).

Timeframe: The growth rate target must be met as a 3-year running geometric mean calculated as the cube root of the product of the growth rates for each of the 3 years (i.e., $(\lambda_1 * \lambda_2 * \lambda_3)^{1/3}$).

Sub-Objective 4 (Reproduction): Maintain fledgling production by breeding pairs sufficient to meet the population growth rate objectives within both the Northern and Southern Regions on the Missouri River.

Metric: Fledge Ratio: Number of fledglings observed/(number of breeding adults/2), calculated annually.

Target: ≥ 1.14 chicks fledged per breeding pair.

Timeframe: The fledge ratio target met as a 3-year running arithmetic mean.

1.4.3 Interior Least Tern Objectives

USFWS has identified the following fundamental objective for the interior least tern:

Interior Least Tern Fundamental Objective: Avoid jeopardizing the continued existence of the endangered interior least tern due to USACE actions on the Missouri River.

As described in Section 1.3, meeting the purpose and need for piping plovers would also achieve the same for the interior least tern. Therefore, sub-objectives, means objectives, metrics and targets for the interior least tern have not been specified. For purposes of this MRRMP-EIS, it is assumed that achieving the stated objectives for the piping plover would also achieve the fundamental objective for the interior least tern.

1.5 Scope of the Plan and Environmental Impact Statement

This EIS assesses the programmatic and cumulative effects of alternatives for implementing the MRRP which include actions necessary to avoid a finding of jeopardy to the federally listed species and associated actions pursuant the Missouri River BSNP mitigation plan during the implementation timeframe of 15 years for this EIS.

This document supersedes the previous MRRP NEPA document entitled *Final Programmatic Environmental Impact Statement for the Mechanical and Artificial Creation and Maintenance of Emergent Sandbar Habitat in the Riverine Segments of the Upper Missouri River* (USACE 2011a). This document does not re-evaluate the entire BSNP Mitigation project but addresses the effects of land acquisition during the implementation timeframe of this EIS. The land acquisition authority and types of habitat development as described in the *Final Supplemental EIS for the Missouri River Fish and Wildlife Mitigation Project* (USACE 2003a), and the *Missouri River Bank Stabilization and Navigation Project Final Feasibility Report and Final EIS for the Fish and Wildlife Mitigation Plan* (USACE 1981) are still considered to be adequate and reasonable to mitigate the effects of the BSNP.

This EIS provides the necessary information for the decision maker to fully evaluate a range of alternatives to best meet the purpose and need of the MRRMP. It fully addresses the potential impacts of alternatives as required under the NEPA of 1969, as amended (42 United States Code (USC) 4321 et seq.); CEQ regulations (40 CFR 1500–1508); and USACE ER 200-2-2 (33 CFR 230). This plan will be reviewed on a regular basis to ensure compliance with applicable laws and regulations, and that circumstances have not changed that would impact the analysis and conclusions reached in the document.

1.5.1 Geographic, Temporal, and Substantive Scope

Project scope is one of the key aspects to fully and accurately define a project's purpose and need. The project's scope provides the important parameters for what is and is not included within the project or study. Scope includes three parameters:

- Temporal scope—the time horizon for this MRRMP-EIS
- Spatial or geographic scope—the area of the plan under analysis and consideration
- Substantive scope—the proposed federal action and focus of the plan

To facilitate plan development, an implementation timeframe of 15 years was chosen for this planning process and EIS. This is a reasonable timeframe for identification of actions which, based on the current state of the science, may provide meaningful biological responses while recognizing the potential that substantive changes to the suite of actions identified in this MRRMP-EIS may be necessary in 15 years based on the AM process. However, effects to resources were based on an 82-year hydrologic period of record (POR) in order to provide an indication of the potential range of effects under the variable hydrologic conditions occurring in the Missouri River basin. The geographic scope of the federal action includes the Missouri River within its meander belt from Fort Peck Dam in Montana to its confluence with the Mississippi River near St. Louis, Missouri, and the Yellowstone River from Intake Dam at Intake, Montana, to its confluence with the Missouri River.

Although prior ESA consultation on System operations included consideration for Kansas River System operations, this EIS did not consider actions on the Kansas River because of low numbers and low productivity of nesting piping plovers and interior least terns on the Kansas River and minimal impacts on interior least tern and piping plover populations when they have been present (USACE 2006c). Additionally, historic catch records for pallid sturgeon are scarce for the Kansas River. In general, pallid sturgeon researchers assume at this time that tributaries are primarily for foraging and/or spawning and it is highly unlikely that this species currently occurs in the Kansas River due to habitat modifications and physical barriers except under high flows (USFWS 2003).

1.5.2 Adaptive Management

The first element of the RPA from the 2003 Amended BiOp requires USACE to use AM as one tool to preclude a finding of jeopardy to interior least terns, piping plovers, and pallid sturgeon. USACE and USFWS agree that future resource management actions in the Missouri River should use an AM framework that recognizes the uncertainties of ecosystem and species responses and attempts to structure management actions to best address those uncertainties. This requires development of objectives and targets, testable hypotheses, predictive modeling, monitoring, assessment, and feedback to decision making so that management actions can be adjusted. In that regard, AM is viewed as a continuous process of actions based on testing, evaluating, informing, and improving.

> ***Adaptive Management****: A decision process that promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process.*

The National Research Council (NRC) describes AM as follows:

> Adaptive management [is a decision process that] promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a

> 'trial and error' process, but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders. (NRC 2004)

An AM approach is being followed in this instance because of scientific uncertainty associated with the pallid sturgeon, interior least tern, and piping plover. AM copes with uncertainty through implementation while acknowledging concerns about the effectiveness of the course of action. Progress can be expected through iterative application of learning and adjustment. AM leads to a better understanding of the resource or system, which in turn leads to improvements in management decisions and their results over time. Three factors are essential for AM to occur: (1) a critical uncertainty, (2) an opportunity to learn, and (3) the ability to adapt decisions based on what was learned (Figure 1-3).

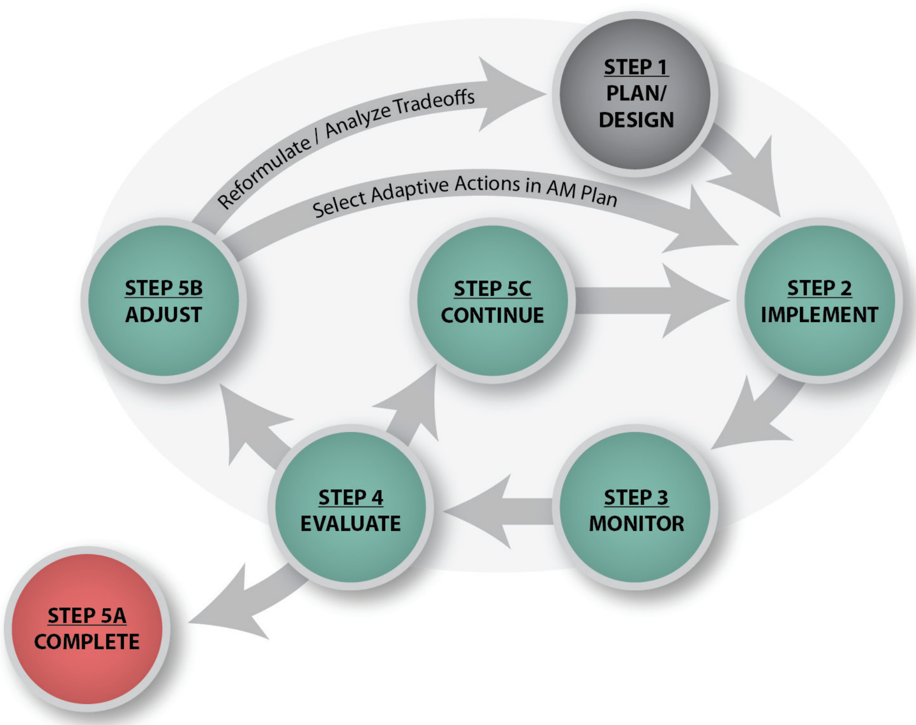

Figure 1-3. Simplified Depiction of the Adaptive Management Process

Using an AM approach, management actions are designed and implemented to test hypotheses and reduce critical uncertainties for the purpose of better informing management decisions. It can be characterized as a cycle of assessing the state of knowledge about species needs and management effectiveness and identifying uncertainties, careful planning and designing of actions to reduce these uncertainties, implementing the planned actions, monitoring and evaluating the results, and then adjusting based on what is learned. Allowing for management flexibility as new learning occurs is a central AM concept. Importantly, the set of management actions that ultimately make up the selected plan should be adjusted over time based on new information entering the decision-making process.

Chapter 2 describes how AM applies to the proposed alternatives, while Chapter 4 summarizes the SAMP under the preferred alternative. The SAMP accompanying this EIS is a detailed description of: the governance structure used for making decisions; the AM framework consisting of management actions, research, monitoring, and evaluation to reduce uncertainties and test hypotheses; human consideration effects monitoring and evaluation; and how scientific information and data will be managed and communicated.

1.5.3 Tiering and Future National Environmental Policy Act Compliance

A programmatic EIS is a strategic approach to meeting an agency's NEPA responsibilities in a cost effective, streamlined manner. Due to the nature of the interrelated federal actions on the Missouri River, a programmatic EIS enables USACE to tier future project proposals from the overarching programmatic EIS analysis, helping to streamline environmental reviews in the future. Tiering, as defined by CEQ regulations, is covering "general matters" in policy or program EISs with subsequent tiered or narrower environmental analyses, while referencing the general discussion and focusing on the project-specific impacts important to the decision maker. It is important that a programmatic EIS is developed in a way that considers how it will be used as well as how future projects will be considered, reviewed, and implemented. The programmatic approach sets the tone for defining the purpose and need for taking action as well as the development of the alternatives. The versatility of a programmatic EIS allows immediate actions to be implemented upon completion of the ROD, given site specific analysis was performed, as well as expediting implementation of future actions under tiered environmental review. A programmatic approach is well suited for the MRRP and it integrates very well with an SAMP. A programmatic EIS allows managers to make decisions more efficiently to change federal actions when monitoring indicates that objectives are not being met, thus strengthening the implementation of an SAMP.

AM is a discretionary management approach that could be used in conjunction with the NEPA process and is encouraged by CEQ for appropriate federal actions (NEPA Task Force 2003). AM and NEPA are similar in that each emphasizes collaboration principles and working with stakeholders and Tribes. AM is consistent with NEPA's goal of informed decision-making: by taking the NEPA process further in addressing uncertainties, data gaps, and potential impacts of AM actions that may be revealed during the AM process so that mid-course corrections can be made based on new learning. By addressing uncertainties and potential impacts associated with potential future AM actions as part of the NEPA process, the need to supplement or prepare additional NEPA documents in the future may be reduced.

This MRRMP-EIS and the SAMP incorporate the components of the MRRP AM process, which have been revised and formalized following the recommendations of MRRIC. Implementation of specific plans or management actions may require subsequent analysis that can be tiered from this EIS. Supplemental NEPA compliance would likely be required if the AM process identifies a need for an action that was not included within the range of impacts and alternatives considered in this EIS or new and significant information affecting the decision and relevant to environmental concerns. These considerations are described further in Chapter 4 of this EIS.

1.6 Structured Decision-Making Process

USACE and USFWS selected a structured decision-making process called PrOACT to assist with the planning and coordination of this MRRMP-EIS. PrOACT provides a systematic approach for making decisions and is compatible with NEPA. The process as implemented for this MRRMP-EIS involves six steps (Figure 1-4):

- Problem Definition
- Objectives
- Alternatives
- Consequences
- Trade-Offs
- Decision – Take Action

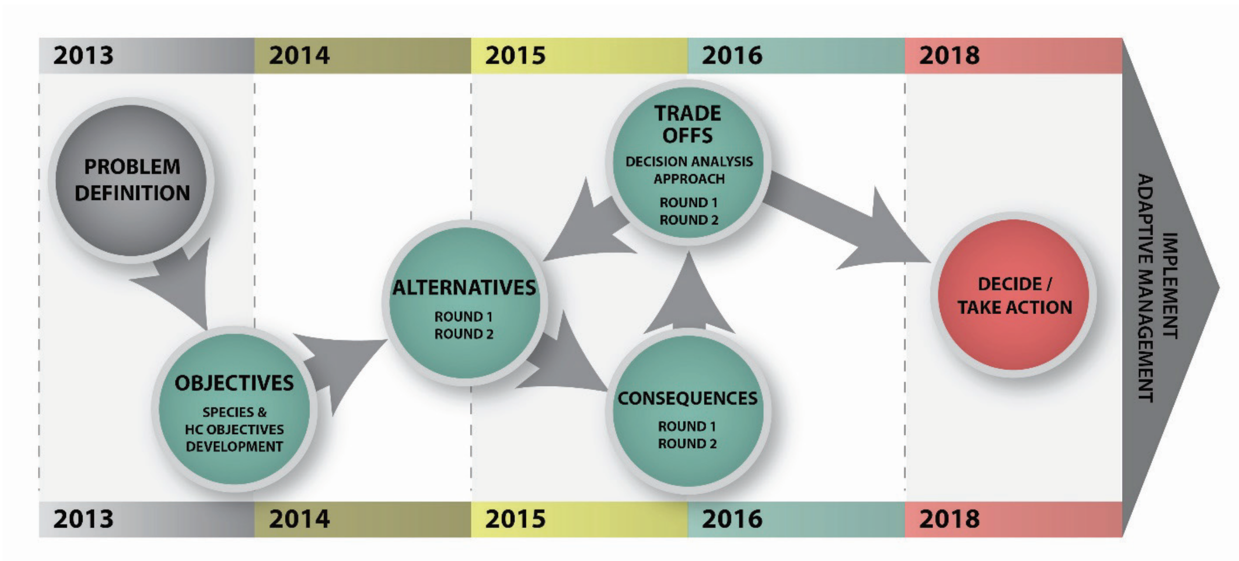

Figure 1-4. PrOACT Process

Based in decision theory, PrOACT encompasses a simple set of concepts and helpful steps rather than a rigidly prescribed approach to problem solving. Additional benefits include the emphasis of PrOACT on collaborative and facilitated decision-making and focus on stakeholder and Tribal involvement in key steps of the planning process. Key concepts include making decisions based on clearly articulated fundamental objectives, dealing with scientific uncertainty, and responding to legal mandates as well as Tribal and public preferences as values in decision making. Thus, PrOACT integrates science and policy directly into the decision-making process. For the evaluation of alternatives, PrOACT confronts uncertainty and the likelihood of multiple outcomes and their possible consequences to help agency decision makers, stakeholders, Tribes, and the public understand the risk associated with each alternative.

The first step in the PrOACT process is to clearly define the problem to be solved. USACE and USFWS established the problem definition for this MRRMP-EIS. The problem definition for this

MRRMP-EIS informs the purpose of the plan and provides important considerations to be evaluated during the decision-making process.

Problem Definition

Develop a management plan that includes a suite of actions that removes or precludes jeopardy status for the piping plover, interior least tern, and pallid sturgeon, and that

- *Continues to serve the Missouri River authorized purposes and accounts for human considerations; and*
- *Includes an EIS and establishes an AM process for implementing the preferred alternative.*

As part of the PrOACT process, USACE, in collaboration with MRRIC, developed environmental impact categories termed "human considerations" representing different natural, social, and economic resources. The impacts on human considerations and other interest categories are described in detail in Chapter 3 of this EIS. The alternatives are designed to meet the species objectives of the plan while taking into account impacts to other resources including human considerations. A comparison of the impacts of the different alternatives is provided in Section 2.9.

USACE and USFWS collaboratively have tailored the generic PrOACT approach to meet the needs of this MRRMP-EIS planning process. NEPA requires federal agencies to prepare an EIS for major federal actions that could significantly impact the quality of the human environment (i.e., natural, social, and economic resources). NEPA also intends the environmental consequences to form the scientific and analytic basis for comparisons of alternatives including the proposed action (40 CFR 1502.16). This EIS fulfills these requirements while incorporating documentation of aspects from the PrOACT process.

1.7 Reservoir System and Bank Stabilization and Navigation Project

1.7.1 Missouri River Mainstem Reservoir System

The Missouri River flows for 2,341 miles from Three Forks, Montana at the confluence of the Gallatin, Madison, and Jefferson Rivers in the Rocky Mountains through the states of Montana, North Dakota, South Dakota, Nebraska, Iowa, Kansas, and Missouri. It is the longest river in the United States. USACE operates the System consisting of six dams and reservoirs with a capacity to store 72.4 million acre-feet (MAF) of water, the largest reservoir system in North America. Combined, the System controls runoff from 279,480 square miles of the upper Missouri River basin (Figure 1-5). It contains 71 percent of the installed capacity in the basin's Federal hydroelectric power system, provides almost all of the reservoir support for downstream flow support on the Missouri River, and contributes greatly to flood risk reduction for over 2 million acres of land in the floodplain of the Missouri River (USACE 2004a). The 1944 Flood Control Act (FCA) authorized the construction and operation of five large dams on the Missouri River Mainstem. The dams authorized by the FCA, along with their reservoirs, are Garrison Dam/Lake Sakakawea in North Dakota; Oahe Dam/Lake Oahe, Big Bend Dam/Lake Sharpe, Fort Randall Dam/Lake Francis Case and Gavins Point Dam/Lewis and Clark Lake in South Dakota. The construction of Fort Peck Dam/Fort Peck Lake in Montana was authorized in the Rivers and Harbors Act of 1935; however, the 1944 FCA incorporated the Fort Peck Dam along with the other five dams and reservoirs to form the System. Today, the System is operated by USACE as an integrated system for the following eight congressionally authorized purposes: flood control, navigation, irrigation, hydropower, water supply, water quality, recreation, and fish and wildlife. USACE operates the System in accordance with the policies and procedures prescribed in the *Missouri River Mainstem Reservoir System Master Water Control Manual* (Master Manual) (USACE 2006a).

In providing System benefits, the construction, operation, and maintenance of the System have resulted in hydrologic alterations to the Missouri River ecosystem including changes to the natural seasonal pattern of river flow and sediment transport. Construction of the six dams converted approximately one third of the Missouri River Mainstem to reservoirs. Dams block upstream passage of native fish species. Dams also trap suspended sediments and construction of the dams coincided with a decline in suspended sediment loads in downstream reaches.

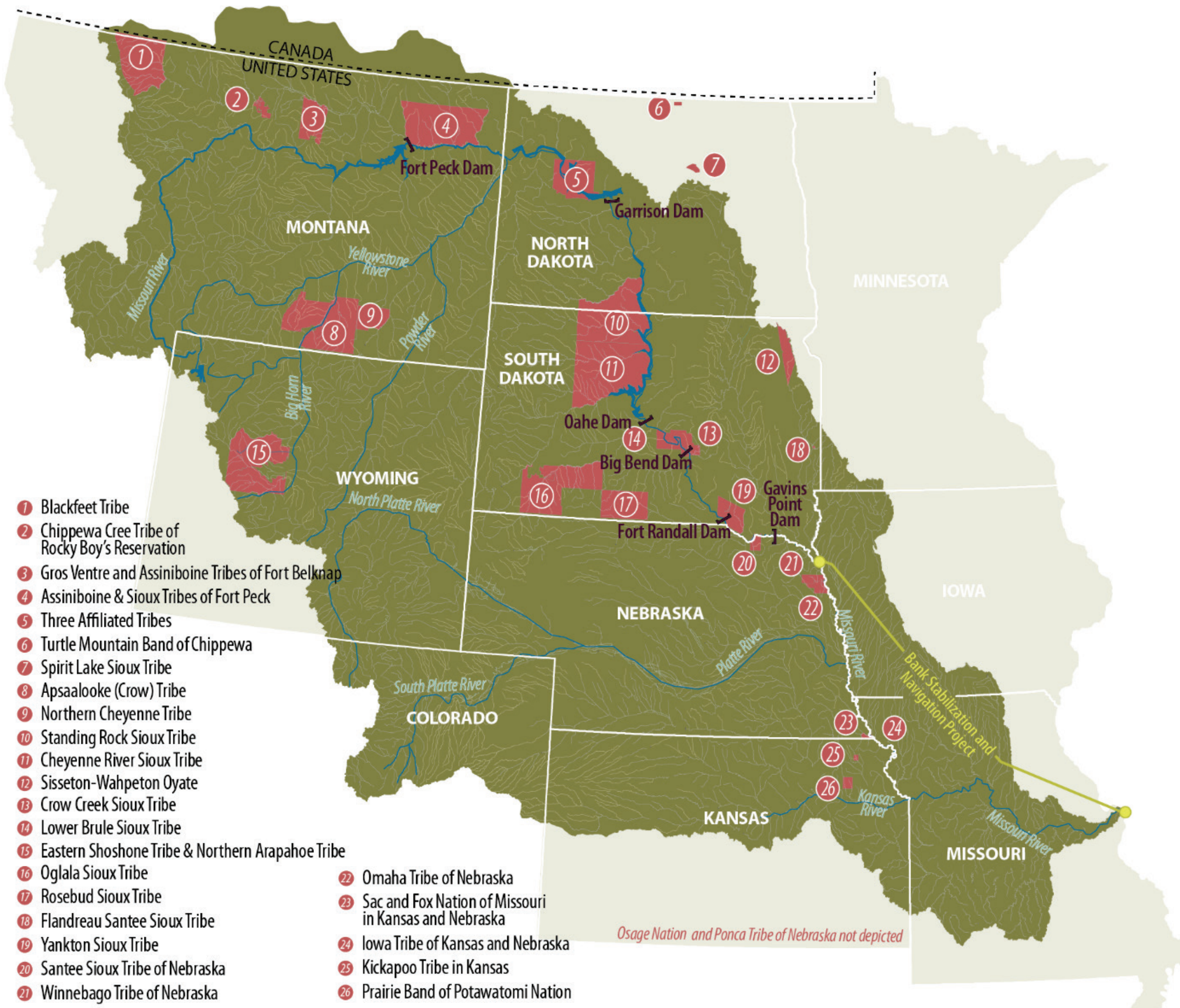

Figure 1-5. Missouri River Mainstem Reservoir System

1.7.2 Kansas River Reservoir System

The Kansas River drains 60,060 square miles of northern Kansas, southern Nebraska, and northeastern Colorado. While no federal reservoirs have been built on the Kansas River, 18 multi-purpose reservoirs, 7 USACE, and 11 U.S. Bureau of Reclamation projects, were built on many of the major Kansas River tributaries. Six USACE projects, Clinton, Perry, Tuttle Creek, Milford, Wilson, and Kanopolis, and one Bureau of Reclamation project, Waconda, are the primary downstream dams in the Kansas River basin with a combined drainage area of 50,852 square miles. The remaining 11 projects, including the USACE Harlan County Dam, are located upstream of Milford, Kanopolis, and Waconda dams. All of the conservation pools of the 11 Bureau of Reclamation projects and Harlan County are operated by the Bureau of Reclamation primarily for irrigation, whereas USACE schedules the flood control operations of all 18 projects. Other authorized purposes of these 18 projects can include water supply, water quality, recreation, and fish and wildlife. Milford, Tuttle Creek, and Perry are also authorized to support navigation flows on the Missouri River. Operation of the Kansas River Reservoir System has decreased the frequency of very high and very low flows. The construction and operation of the federal reservoirs on the Kansas River Reservoir System have also trapped tributary sediment, precluding its introduction into the Mainstem (USFWS 2000).

1.7.3 Missouri River Bank Stabilization and Navigation Project

Shortly after Lewis and Clark explored the Missouri River, the Federal Government started efforts to modify the Missouri River to support navigation. Starting as early as 1819, funds were appropriated by Congress to survey the river; remove river habitat features viewed as obstructive, such as snags, and to confine the river by locking its banks at specified locations. Beginning in 1912, Congress passed the first of several laws (Rivers and Harbors Acts of 1912, 1925, 1927, 1935, and 1945) to fund work by USACE to further improve the river for navigation. This work would later become known as the BSNP. The BSNP features authorized by these laws would further confine the natural river by providing for a comparably static, uniform depth, width, and length. From 1932 to 1973, USACE regularly dredged areas of the navigation channel that were prone to deposition. The BSNP consists mainly of rock pile structures and revetments along the outsides of bends and transverse dikes along the insides of bends to force the river into a channel alignment that is self-maintaining or self-scouring. This is different from most inland navigation systems, which are managed through the use of locks with some associated dredging. Training structures permit an open condition for the entire length of the project with no dredging required under normal flow conditions. As authorized, the BSNP provides a 9-foot-deep channel with a minimum width of 300 feet during the navigation season from April 1 to November 30 between Sioux City, Iowa, and the mouth near St. Louis, Missouri. Releases from the System are necessary to provide the authorized navigation channel dimensions. The need for maintenance dredging dropped sharply in the early 1970s as a result of the structures' confining features. Construction of the BSNP was completed in 1981. The Missouri River was shortened by approximately 45 miles between Rulo, Nebraska, and the mouth between 1879 and 1972, due in large part to the construction of the BSNP (Funk and Robinson 1974). Figure 1-6 illustrates the changes over time that resulted from construction of the BSNP.

Figure 1-6. Changes to the River from Missouri River Bank Stabilization and Navigation Project Construction (Indian Cave Bend, Nebraska)

1.8 Endangered Species Act and BSNP Fish and Wildlife Mitigation

1.8.1 Endangered Species Act Compliance

USACE has a responsibility under the ESA to take actions to ensure that the operation of the Missouri River is not likely to jeopardize the continued existence of threatened and endangered species or destroy or adversely modify designated critical habitat. Beginning in 1987, USFWS and USACE engaged in consultation in compliance with Section 7 of the ESA, concerning impact of current reservoir operations on the listed birds which resulted in a 1990 BiOp with a finding of jeopardy. These consultations continued after the pallid sturgeon was listed and later included proposed reservoir operations under the revised Master Manual and the operation and maintenance of the BSNP. In November 2000 USFWS issued the *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* (USFWS 2000). The 2000 BiOp concluded that operating the System, operating and maintaining the BSNP, and operating the Kansas River Reservoir System, as proposed, would jeopardize the continued existence of the federally listed pallid sturgeon, interior least tern, and piping plover.

> ***Jeopardy**: Occurs when an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species.*
>
> ***Recovery**: An improvement in the status of listed species to the point at which listing is no longer appropriate under the ESA.*

The BiOp, which applies to the portion of the Missouri River from Fort Peck, Montana, to St. Louis, Missouri, identified an RPA to avoid a finding of jeopardy; the RPA consists of several actions to be taken by USACE. Any incidental take of listed species that could occur by implementing an RPA and the agency's action is also addressed in the incidental take statement of the BiOp. The incidental take statement provides nondiscretionary measures that are necessary and appropriate to minimize the impact of incidental take. These reasonable and prudent measures (RPMs) are to be taken within the action area, involve only minor changes to the project, and reduce the level of take associated with project activities.

> ***Reasonable and Prudent Alternative (RPA)**: A recommended alternative action that can be*
>
> - *implemented in a manner consistent with the intended purpose of the federal action*
> - *implemented consistent with the scope of the federal agency's legal authority and jurisdiction*
> - *economically and technologically feasible*
>
> *and that USFWS finds would avoid the likelihood of jeopardizing the continued existence of a listed species or the destruction or adverse modification of designated critical habitat.*

The RPA in the 2000 BiOp consisted of six major actions: (1) AM and monitoring; (2) flow enhancement; (3) unbalanced intrasystem regulation; (4) habitat restoration, creation, and acquisition (including construction of SWH to benefit the pallid sturgeon and ESH for the benefit of interior least terns and piping plovers); (5) interior least tern and piping plover species-specific actions; and (6) pallid sturgeon propagation, augmentation, and population/habitat assessment. The habitat restoration, creation, and acquisition would, in part, be implemented through the existing fish and wildlife mitigation project which is required to offset portions of the impacts caused by the BSNP. In addition, the 2000 BiOp included 11 RPMs to minimize the take of bald eagles, interior least terns, piping plovers, and pallid sturgeon.

The flow enhancement plan presented in the 2000 BiOp RPA consisted of a spring rise and a lowered summer flow downstream of Gavins Point Dam. This was hypothesized to create a spawning cue for fish, maintain and develop sandbar habitat for birds and fish, and improve the connection between the main channel and backwaters and side channels, among other benefits. A spring rise was also identified below Fort Peck Dam. These spring rises were scheduled to start no later than 2003. However, they were never implemented. In November 2003, USACE reinitiated formal consultation with USFWS, providing a BA with new proposed actions. Consultation was reinitiated because new information concerning the effects of USACE actions that had previously not been considered and because USACE believed certain components of the RPA did not comport with the regulatory criteria for an RPA (USACE 2003a). Additionally, critical habitat had been designated for the piping plover, new information on the mortality of interior least terns and piping plovers was available, and an updated hydrology and hydraulics analysis indicated that some flow modifications could erode more ESH than they would create. In 2003, USFWS provided a determination that the new USACE proposed action would avoid jeopardizing the continued existence of the two listed bird species, but continued to appreciably reduce the likelihood of both survival and recovery of the pallid sturgeon, thus jeopardizing its continued existence in the wild (USFWS 2003). USFWS then amended the 2000 BiOp to remove the flow modifications previously provided in the RPA, and concluded that mechanical and artificial creation of ESH for replacement was an acceptable means to avoid a finding of jeopardy to the interior least tern and piping plover. The 2003 Amended BiOp retained the majority of RPA actions described in the 2000 BiOp; however, it added new RPA elements to the flow enhancement action. Fifteen new RPMs to minimize take of interior least terns and piping plovers were included in the 2003 amended BiOp replacing the RPMs in the 2000 BiOp. In October 2018, USACE provided a new BA to USFWS. Based on the new BA, USFWS determined that there would be no jeopardy to the least tern, piping plover, or pallid sturgeon from implementation of the USACE Proposed Action which includes:

- Missouri River Mainstem System Operations
- BSNP Operations and Maintenance
- Kansas River Operations
- Least Tern and Piping Plover Management Actions
- Pallid Sturgeon Management Actions
- Adaptive Management
- Section 7(a)(1) Conservation Plan

1.8.2 BSNP Fish and Wildlife Mitigation Project

The Fish and Wildlife Coordination Act (16 USC 661 et seq.) contemplates land acquisition for project mitigation, within the parameters of specific language in individual project authorizations. The Act requires federal agencies to undergo consultation with USFWS for all projects that control, modify, or divert water prior to carrying out the project. In 1958, an amendment to early forms of this law (P.L. 85-624, August 12, 1958, 72 Stat. 563) gave the Act its current name, established most of its structure, and required equal consideration and coordination of wildlife conservation with other water resource development programs. It also required any report to

Congress supporting a recommendation for authorization of a project to include an estimation of the wildlife benefits or losses, the cost of offsetting wildlife losses and other related information. In addition to new projects, those projects that were less than 60 percent complete in 1958 were subject to consultation within this framework. The BSNP was 58 percent complete on August 12, 1958, the day the Act was signed into law. As the BSNP neared completion, USACE commenced work on a Chief of Engineers' Report to Congress (Chief's Report) pursuant to the Fish and Wildlife Coordination Act. The Chief's Report, submitted April 24, 1984, set forth a recommended plan for the BSNP to achieve its mitigation as identified in the *Missouri River Bank Stabilization and Navigation Project Final Feasibility Report and Environmental Impact Statement for the Fish and Wildlife Mitigation Plan* (completed in 1981). The report included mitigation measures to offset some of the adverse impacts to fish and wildlife habitat caused by the BSNP.

Section 601 of WRDA 1986 adopted this plan and established the mitigation program "for mitigation of fish and wildlife losses" as identified in the Chief's Report. It also required the Chief of Engineers to study the need for additional mitigation measures and report back. Congress authorized the Missouri River BSNP Fish and Wildlife Mitigation Project in the WRDA of 1986, Section 610 (a) for a total of 48,100 acres of fish and wildlife habitat. Beginning in 1992, Congress appropriated funds for project construction through the Energy and Water Appropriations Act to mitigate for adverse impacts caused by the BSNP. Section 334 of WRDA 1999 increased the acreage of habitat to be mitigated for the Mitigation Project by 118,650 bringing the total acres to be mitigated to 166,750 acres. This authorized acreage is roughly 35 percent of the 474,600 acres of fish and wildlife habitat lost between 1912 and 1980 due to construction of the BSNP (USFWS 1980). To date, approximately 66,000 acres have been acquired in fee title or easement towards the BSNP mitigation authority. The BSNP Mitigation Project authority was further amended in Section 3176(a) of WRDA 2007 allowing funds made available for recovery or mitigation activities in the lower basin of the Missouri River to be used in the upper basin of the Missouri River, including the states of Montana, Nebraska, North Dakota, and South Dakota.

Since the WRDA 1986 authorization, the pallid sturgeon was federally listed as an endangered species under the ESA. USFWS identified aquatic habitat development as a critical element of the RPA contained in the 2003 Amended BiOp. Specifically, the critical element was to achieve a SWH goal of 20–30 acres per mile over the length of the 735-mile Missouri River BSNP. The land acquisition authority used by the MRRP for BiOp compliance is derived from Section 601 of WRDA 1986, as amended by Section 334 of WRDA 1999 and Section 3176 of WRDA 2007. This authority is limited to habitat mitigation for the effects of the BSNP and therefore cannot be separated from the requirement that lands acquired also serve to offset the impacts of the BSNP. USACE has no independent authority to acquire land for ESA compliance along the Missouri River, but USACE is able to acquire lands in areas that also constitute a necessary and proper expense under the WRDA land acquisition authority. It is similarly important to note that mere land acquisition, in and of itself, does not necessarily equate to mitigation under the authorizations. Land acquisition is a means to accomplish mitigation in that it allows for USACE to restore or preserve lost fish and wildlife habitat of the lower Missouri River, which accomplishes the authorization's purpose of replacement of fish and wildlife losses.

1.9 Missouri River Recovery Program

1.9.1 Missouri River Recovery Program and the Missouri River Recovery Implementation Committee

The MRRP was established by USACE in 2005. It is the umbrella program that coordinates USACE efforts in the following:

- ESA compliance for the Operation of the Missouri River Main Stem Reservoir System, Operation and Maintenance of the BSNP, and Operation of the Kansas River Reservoir System;
- Acquiring and developing lands to mitigate for lost habitats as authorized in Section 601(a) of WRDA 1986 and modified by Section 334(a) of WRDA 1999 (collectively known as the BSNP Fish and Wildlife Mitigation Project); and
- Implementation of WRDA 2007 including MRRIC and Section 3176, which allowed USACE to use recovery and mitigation funds in the upper basin states of Montana, Nebraska, North Dakota, and South Dakota.

On July 1, 2008, the Assistant Secretary of the Army for Civil Works provided implementation guidance thereby adopting the MRRIC charter pursuant to congressional authorization set forth in WRDA 2007. MRRIC makes recommendations and provides guidance to federal agencies on the existing MRRP. MRRIC is composed of over 70 members representing various interests, Tribes, states, and agencies from within the Missouri River basin.

1.9.2 Effects Analysis

As described in Section 1.3, USACE initiated an effects analysis subsequent to receiving MRRIC's recommended actions. The concept of an effects analysis is rooted in the requirement within the ESA to evaluate the effects of actions proposed by federal agencies on listed species or designated critical habitat, using the best available science. Completion of an effects analysis includes defining the proposed action, identifying the area affected, and developing conceptual models with written descriptions and visual representations of the physical and biological relationships between actions and species responses (Murphy and Weiland 2011). Murphy and Weiland (2011) advocated for a rigorous approach to the effects analysis that consists of three primary steps. The first step is to collect reliable scientific information, including observations about the stressor and the range of stressor conditions and information on population sizes and trends. The second step includes assessment of the data, including using quantitative models to integrate existing information and identifying and representing uncertainties. The third step is to analyze the effect of the actions on the species to determine costs and benefits and identify alternatives.

The effects analysis team formed to support the MRRP efforts has been responsible for development of CEMs as well as the three primary steps described previously. Comprehensive CEMs were developed to link species' population dynamics to potential management actions and other stressors, based on current scientific understanding. These CEMs provide a broad framework of the factors affecting species population dynamics and are explained in more detail in Chapter 2 of this EIS. Concurrently, available scientific literature, databases, and models on the three species were compiled, reviewed, and synthesized, and will be updated over time. Based on the CEMs and literature synthesis, hypotheses were developed about the effects of potential management actions on each species and their habitat. The effects analysis has also developed predictive and quantitative models that explore system dynamics and population responses to alternative management actions, and assess the effects of potential management actions on species populations and habitats. The effects analysis results and products form the foundation for development of the MRRMP-EIS alternatives and the comprehensive AM approach recommended by ISAP. Figure 1-7 illustrates the timeline of events leading to this MRRMP-EIS.

-1985-	May 1985 / Interior least tern listed as endangered species
-1986-	1986 / Section 601 of WRDA 1986 authorizing USACE to develop 48,100 acres of fish and wildlife habitat on public and private lands to mitigate for loss of habitat as a result of the BSNP between Ponca, NE and the mouth at St. Louis, MO. December 1986 / Piping plover listed as threatened species
-1987-	1987 / Missouri River Operations (MOR) biological assessment
-1989-	November 1989 / Missouri River Master Water Control Manual Review and Update Study initiated
-1990-	October 1990 / Pallid sturgeon listed as endangered species November 1990 / Biological Opinion on Missouri River operations for birds
-1994-	July 1994 / Missouri River Master Water Control Manual Review and Update Study Draft Environmental Impact Statement Published August 1994 / Draft Biological Opinion on Master Manual DEIS Preferred Alternative Published
-1997-	October 1997 / Biological Assessment on MIssouri River operations (post listing of the birds)
-1998-	December 1998 / Biological Assessment on MIssouri River operations
-1999-	1999 / Section 334 of WRDA 1999 authorizing USACE to acquire an additional 118,650 acres in the Missouri River floodplain to restore or preserve fish and wildlife habitat between Ponca, NE and the mouth at St. Louis April 1999 / Biological Assessment on BSNP O&M
-2000-	November 2000 / USFWS Biological Opinion published
-2001-	August 2001 / Missouri River Master Water Control Manual Review and Update Study Revised Draft EIS Published
-2002-	January 2002 / National Academy of Sciences Report Released
-2003-	2003 / BSNP SEIS and ROD November 2003 / Biological Assessment for Missouri River operations & BSNP O&M December 2003 / Amended USFWS Biological Opinion published
-2004-	March 2004 / Record of Decision on Master Manual study/EIS
-2005-	2005 / Missouri River Recovery Program Initiated June – August 2005 / Spring Pulse Plenary Group
-2006-	March 2006 / Master Manual revised to include bimodal spring pulse technical criteria March 2006 / Spring Pulse Environmental Assessment May 2006 / Gavins Point single spring pulse implemented
-2007-	2007 / MRRIC authorized by WRDA 2007 / Section 3176 of WRDA 2007 authorizing the USACE to use funds made available for recovery or mitigation activities in the lower basin for recovery or mitigation activities in the upper basin
-2008-	March 2008 / Gavins Point single spring pulse implemented July 2008 / MRRIC charter adopted September 2008 / First MRRIC Meeting
-2009-	May 2009 / Gavins Point single spring pulse implemented
-2011-	2011 / ISAP established by MRRIC/USACE November 2011 / ISAP Final Report on Spring Pulses and Adaptive Management published
-2013-	January 2013 / Notice of Intent to prepare an EIS for the MRRMP published in Federal Register September 2013 / Effects Analysis initiated September 2013 / Public Scoping period
-2014-	January 2014 / interim draft conceptual ecological models for pallid sturgeon, least tern, and piping plover May 2014 / interim draft of working hypotheses linking management of the Missouri River to pallid sturgeon, least tern, and piping plover population dynamics October 2014 / interim draft of effects analysis integrative reports for pallid sturgeon, least tern, and piping plover
-2016-	December 2016 / Draft MRRMP-EIS published
-2017-	October 2017 / Biological Assessment for Missouri River operations & BSNP O&M
-2018-	April 2018 / 2018 USFWS Biological Opinion August 2018 / Final MRRMP-EIS published

Figure 1-7. Timeline of Events Leading to the Missouri River Recovery Management Plan and Environmental Impact Statement

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Chapter 2 Alternatives

The National Environmental Policy Act (NEPA) requires federal agencies to evaluate and consider a range of alternatives that address the purpose of and need for action. Alternatives under consideration must include a "No Action" alternative in accordance with Council on Environmental Quality (CEQ) regulations (40 CFR 1502.14). As described in CEQ's *Forty Most Asked Questions Concerning CEQ's NEPA Regulations* (Question 3), "No Action" is best defined as "no change" from current management direction or level of management intensity in situations that involve updating management plans or ongoing programs. For this plan, the No Action alternative does not mean taking no action at all, it is a continuation of the actions currently being used to comply with the 2003 Amended Biological Opinion (BiOp) (USFWS 2003). Differences between alternatives are shown by comparing the impacts of the No Action alternative and the action alternatives.

This chapter describes the alternatives development process and decision-making rationale used for this Missouri River Recovery Management Plan and Environmental Impact Statement (MRRMP-EIS). The No Action alternative (Alternative 1) and five action alternatives are described. Alternatives 1 and 2 focus on implementing the current BiOp; whereas Alternatives 3–6 represent alternative means to meet the purpose and need for taking action. Actions and alternatives that were considered but eliminated from detailed analysis are also discussed.

2.1 Overview of Alternative Development Process

An interdisciplinary planning team made up of experts from multiple federal agencies in collaboration with basin stakeholders and Tribes participated in alternatives development. Alternatives were developed in accordance with CEQ's NEPA implementing regulations (40 CFR 1500–1508). The goal was to formulate a set of reasonable alternatives to meet the species objectives described in Chapter 1 and clearly articulate the effects of those alternatives to provide necessary information to decision makers, stakeholders, Tribes, and the public. The team used an iterative development process to identify and screen management actions and alternatives. Alternatives development built on the purpose, need, and objectives development steps, and was guided by the effects analysis results and products, which provide the scientific foundation for the development and evaluation of management actions. Critical components of the effects analysis process including creation of conceptual ecological models (CEMs), hypotheses development, and development of supporting models are summarized in this chapter.

The formulation of alternatives is an iterative process that increases the level of detail at each iteration so as to allow better decisions about which alternatives to continue to move forward for consideration by decision makers. The alternatives formulation process generally consisted of the following sequence of steps:

- Identification and consideration of general management actions
- Modeling and evaluation of potential management actions
- Screening of management actions
- Formulation of species alternatives
- Modeling and evaluation of potential species alternatives
- Screening of species alternatives
- Selection of plan alternatives for detailed evaluation in the EIS

2.2 Effects Analysis Products and Results

The MRRMP-EIS alternatives development process relied on and was substantively informed by the effects analysis.

The effects analysis and associated products summarize the best available information to evaluate the effectiveness of management actions. USACE and U.S. Fish and Wildlife Service (USFWS) used the effects analysis information to ensure that up-to-date science informed alternatives that were developed and assessed.

One of the primary products from the effects analysis were CEMs. CEMs are graphical depictions of an ecosystem that are used to communicate the important components of the system and their relationships. They are a representation of the current scientific understanding of how the system works. They can take the form of any combination of narratives, tables, matrices of factors, or box-and-arrow diagrams. CEMs are frequently cited as a necessary step in formal adaptive management (AM), in which stakeholders, Tribes, and scientists jointly develop a shared understanding of what influences an ecosystem or population, and then apply the model to predictions of system behavior (i.e., hypotheses) under management scenarios (Walters 1986). CEMs were developed by the effects analysis team to link species population dynamics to potential management actions and other stressors (i.e., actions or factors that have a negative influence on the species population). The CEMs were an important step in the process leading to alternatives development because they formed the basis for identifying hypotheses and developing quantitative predictive models.

The CEMs for piping plovers, least terns, and their habitat relate drivers (social, political, legal, economic, climate, geology, and land ownership) to Missouri River management, hydrology, and habitat. They then relate biotic processes such as nesting behavior, predation and food availability, and dispersal to habitat availability. These biotic factors then affect survival and reproduction to ultimately determine population size. Figure 2-1 illustrates an overview of the CEMs for piping plovers and least terns. The piping plover and least tern CEMs and the process of developing them are documented in Buenau et al. (2016a).

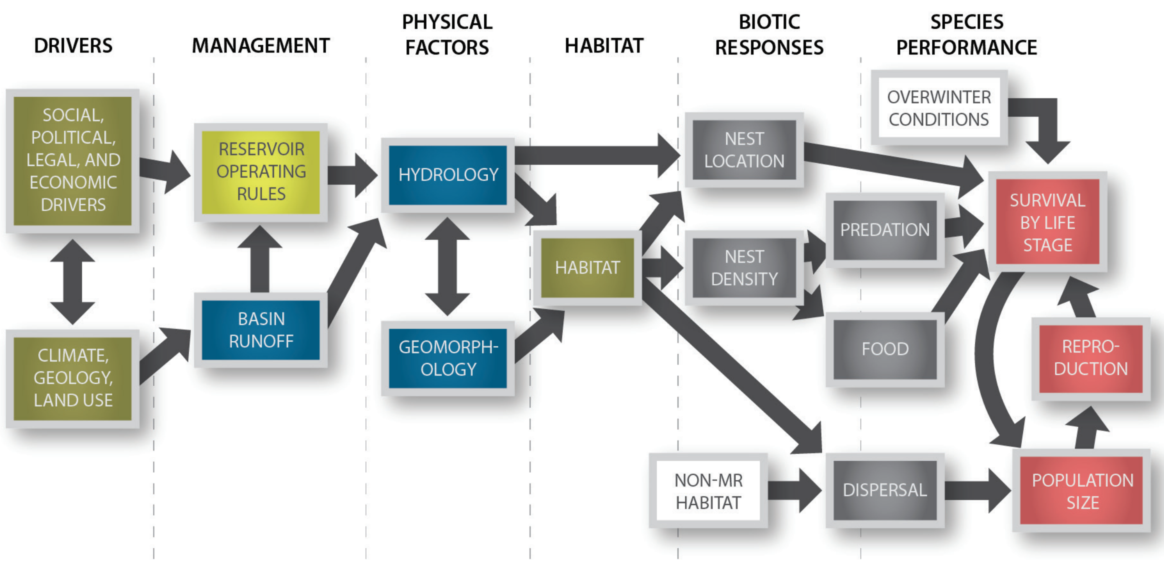

Figure 2-1. Example Conceptual Ecological Model for Piping Plover and Least Tern

Pallid sturgeon CEMs illustrate population dynamics and show the linkage between management actions, ecological factors, and biological responses. The pallid sturgeon CEMs consist of a generalized population-level CEM (Figure 2-2) and a series of life-stage component CEMs. The generalized population-level CEM demonstrates the conditions, processes, and potential management actions that affect survival at critical life-stage transitions. The pallid sturgeon CEMs and the process of developing them are documented in Jacobson et al. (2015a).

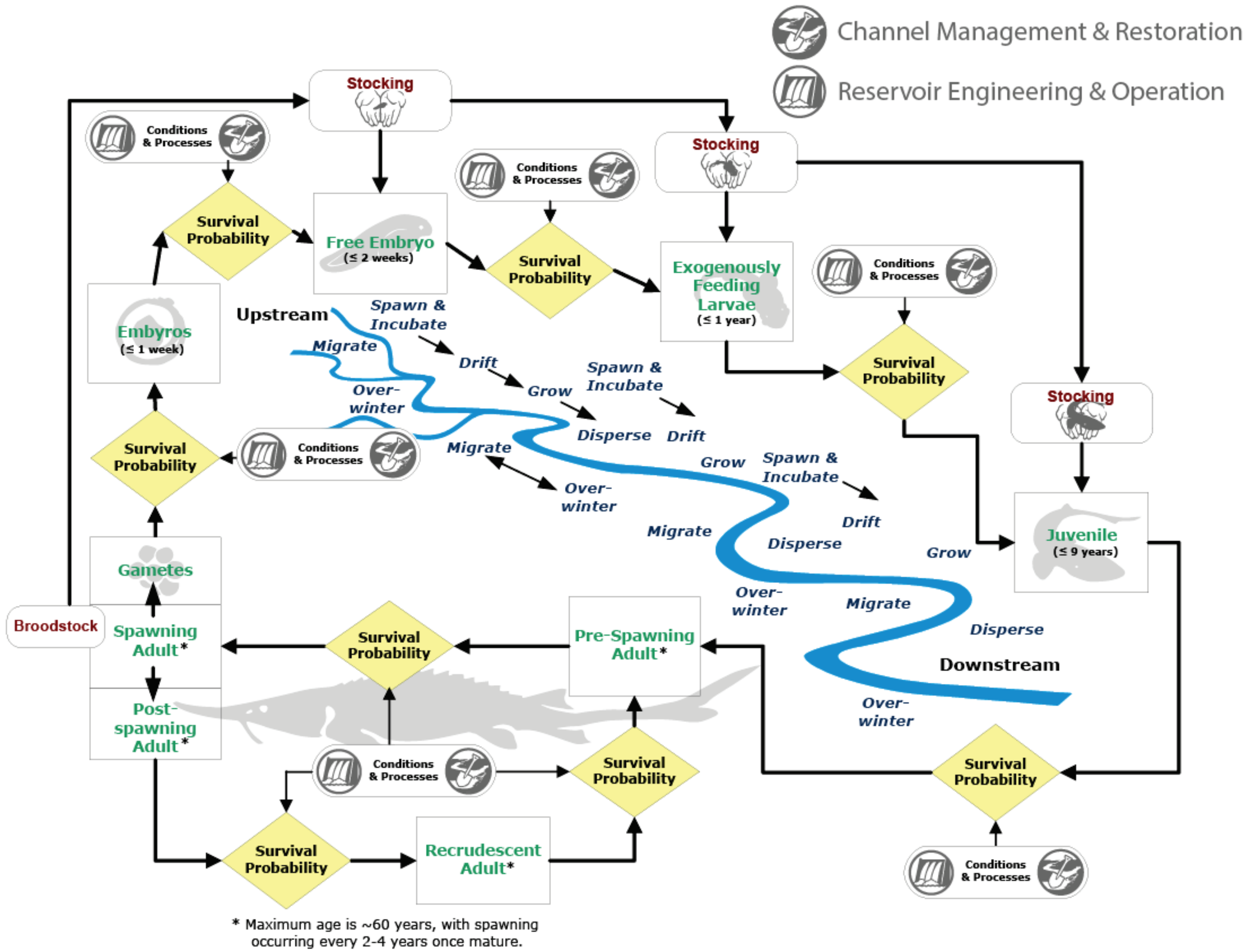

Figure 2-2. Pallid Sturgeon Generalized Population-Level Conceptual Ecological Model

2.3 Identification of Management Hypotheses

The CEMs served as the starting point for development of management hypotheses, which in turn were the basis for identifying general management actions considered in formulating alternatives. Hypotheses were developed directly from the piping plover and least tern CEMs by tracing pathways through CEM components linking physical factors to species performance (Buenau et al. 2016a). Many of the bird management hypotheses are focused on habitat and these hypotheses apply to both piping plovers and least terns. This was an appropriate approach because of the central role of nesting and brood-rearing habitat as a mediating factor between hydrology and geomorphology and the biotic responses in the bird CEMs, as well as the similarities between least tern and piping plover nesting habitat (Buenau et al. 2016a). Table 2-1 identifies the management hypotheses and their associated general management actions for piping plover and least tern. Buenau et al. (2016a) describes the process of developing the bird management hypotheses in more detail.

Table 2-1. Least Tern and Piping Plover Management Hypotheses and Associated General Management Actions

Management Hypothesis	General Management Action
Habitat-creating flows of sufficient magnitude and duration increase the area of nesting/brood rearing habitat and foraging habitat on the river by increasing deposition, assuming sediment is available, thereby increasing fledging productivity.	Habitat-creating flow release
Mechanical habitat creation of sandbars in river segments increases nesting/brood-rearing and foraging area, which increases survival of eggs to chicks and chicks to fledglings by reducing predation and increasing food availability.	Mechanical habitat creation on river
Mechanical habitat creation of sandbars in river segments increases nesting/brood-rearing and foraging area relative to the condition and availability of habitat at other breeding areas, thus increasing the number of adults through net immigration from other areas.	
Mechanical habitat creation of habitat on reservoir shorelines/islands increases nesting/brood-rearing and foraging area, which increases survival of eggs to chicks and chicks to fledglings by reducing predation and increasing food availability.	Mechanical habitat creation on reservoir shorelines or islands
Mechanical habitat creation of habitat on reservoir shorelines/islands increases nesting/brood-rearing and foraging area relative to the condition and availability of habitat at other breeding areas, thus increasing the number of adults through net immigration from other areas.	
Mechanical habitat creation of habitat other than emergent sandbar habitat (ESH) or in segments outside of the current ESH scope increases nesting/brood-rearing and foraging area, which increases survival of eggs to chicks and chicks to fledglings by reducing predation and increasing food availability.	Mechanical creation of hydrologically connected non-ESH habitat on river segments
Mechanical habitat creation of habitat other than ESH or in segments outside of the current ESH scope increases nesting/brood-rearing and foraging area relative to the condition and availability of habitat at other breeding areas, thus increasing the number of adults through net immigration from other areas.	

Management Hypothesis	General Management Action
Modification or augmentation of existing sandbars increases nesting/brood-rearing and foraging area, which increases survival of eggs to chicks and chicks to fledglings by reducing predation.	Modification or augmentation of existing sandbars
Modification or augmentation of existing sandbars increases nesting/brood-rearing and foraging area, which increases survival of chicks to fledglings by increasing food availability.	
Modification or augmentation of existing sandbars increases nesting/brood-rearing and foraging area relative to the condition and availability of habitat at other breeding areas, thus increasing the number of adults through net immigration from other areas.	
Vegetation removal increases nesting/brood-rearing and foraging area, which increases survival of eggs to chicks and chicks to fledglings by reducing predation (by increasing area and by removing cover for predators).	Vegetation removal
Vegetation removal increases nesting/brood-rearing and foraging area, which increases survival of chicks to fledglings by increasing food availability.	
Vegetation removal increases nesting/brood-rearing and foraging area relative to the condition and availability of habitat at other breeding areas, thus increasing the number of adults through net immigration from other areas.	
Habitat-conditioning flows are not of sufficient magnitude and duration to create new sandbars, but scour vegetation or deposit new sediment on existing bars, increasing the area of nesting/brood-rearing habitat, thereby increasing fledgling productivity.	Habitat-conditioning flows
Declining reservoir water levels between years and/or steady or declining water levels during the nesting season increases the area of suitable nesting/brood rearing and plover foraging habitat on the reservoirs, thereby increasing fledgling productivity.	Reservoir water level management
Lowered nesting season flows increase the area of suitable nesting and brood rearing habitat and foraging habitat on the river, thereby increasing fledgling productivity.	Lowered nesting season flows
Steady or declining reservoir levels and/or river flows during the nesting season increases survival from egg to chick and chick to fledgling by reducing the risk of nest inundation and chick stranding and by maintaining or increasing foraging habitat.	Flow management to reduce take
Predator removal increases survival of eggs to chicks and chicks to fledglings.	Predator removal
Nest caging protects plover nests from predators, increasing survival of eggs to chicks, though survival of adults may be negatively affected by cages.	Nest caging
Human restriction measures reduce human activity on nesting and foraging habitat, increasing survival both by decreasing direct mortality and indirect effects on survival caused by stress.	Human restriction measures

The interaction between the System and pallid sturgeon is more complex and as a result, a more intensive filtering process was applied to the identification of pallid sturgeon management hypotheses (Jacobson et al. 2016a). The hypothesis filtering approach was used to determine 21 management hypotheses separated by upper river pallid sturgeon (Table 2-2) and lower river pallid sturgeon (Table 2-3). As with the birds, the process began by identifying the implicit hypotheses from the pallid sturgeon component CEMs. A series of workshops were used to filter these hypotheses and link these hypotheses to management actions (Jacobson et al. 2016a).

Table 2-2. Upper River Pallid Sturgeon Management Hypotheses and Associated General Management Actions

Management Hypothesis	General Management Action
Naturalized flow releases at Fort Peck will result in increased productivity through increased hydrologic connections with low-lying land and floodplains in the spring, and decreased velocities and bioenergetic demands on exogenously feeding larvae and juveniles during low flows in summer and fall.	Alter flow regime at Fort Peck
Attractant flow releases at Fort Peck will result in increased reproductive success through increased aggregation and spawning success of adults.	
Reduction of Mainstem Missouri flows from Fort Peck Dam during free embryo dispersal will decrease Mainstem velocities and drift distance thereby decreasing mortality by decreasing numbers of free embryos transported into headwaters of Lake Sakakawea.	
Warmer flow releases at Fort Peck will increase System productivity and food resource availability, thereby increasing growth and condition of exogenously feeding larvae and juveniles.	Temperature control, Fort Peck
Warmer flow releases from Fort Peck will increase growth rates, shorten drift distance, and decrease mortality by decreasing free embryos transported into headwaters of Lake Sakakawea.	
Installing sediment bypass at Fort Peck will increase and naturalize turbidity levels, resulting in decreased predation on embryos, free embryos, and exogenously feeding larvae.	Sediment augmentation, Fort Peck
Fish passage at Intake Diversion Dam on the Yellowstone River will allow access to additional functional spawning sites, increasing spawning success and effective drift distance, and decreasing downstream mortality of free embryos and exogenously feeding larvae.	Fish passage at Intake on Yellowstone River
Stocking at optimal size classes and in optimal numbers will increase growth rates and survival of exogenously feeding larvae and juveniles.	Upper basin propagation
Stocking with appropriate parentage and genetic diversity will result in increased survival of embryos, free embryos, exogenously feeding larvae, and juveniles.	
Drawdown of Lake Sakakawea will increase effective drift distance, decreasing downstream mortality of free embryos and exogenously feeding larvae.	Drawdown Lake Sakakawea

Table 2-3. Lower River Pallid Sturgeon Management Hypotheses and Associated General Management Actions

Management Hypothesis	General Management Action
Naturalization of the flow regime at Gavins Point will improve flow cues in spring for aggregation and spawning of reproductive adults, increasing reproductive success.	Alter flow regime at Gavins Point
Naturalization of the flow regime at Gavins Point will improve connectivity with channel-margin habitats and low-lying floodplain lands, increase primary and secondary production, and increase growth, condition, and survival of exogenously feeding larvae and juveniles.	
Naturalization of the flow regime at Gavins Point will decrease velocities and bioenergetic demands, resulting in increased growth, condition, and survival for exogenously feeding larvae and juveniles.	
Alteration of the flow regime at Gavins Point can be optimized to decrease Mainstem velocities, decrease effective drift distance, and minimize mortality.	

Management Hypothesis	General Management Action
Operation of a temperature management system at Fort Randall and/or Gavins Point will increase water temperature downstream of Gavins Point, providing improved spawning cues for reproductive adults.	Temperature management, Gavins Point
Re-engineering of channel morphology in selected reaches will create optimal spawning conditions—substrate, hydraulics, and geometry—to increase probability of successful spawning, fertilization, embryo incubation, and free-embryo retention.	Channel reconfiguration
Re-engineering of channel morphology in selected reaches will increase channel complexity and bioenergetic conditions to increase prey density (invertebrates and native prey fish) for exogenously feeding larvae and juveniles.	
Re-engineering of channel morphology will increase channel complexity and minimize bioenergetics requirements for resting and foraging of exogenously feeding larvae and juveniles.	
Re-engineering of channel morphology in selected reaches will increase channel complexity and serve specifically to intercept and retain drifting free embryos in areas with sufficient prey for first feeding and for growth through juvenile stages.	
Stocking at optimal size classes and in optimal numbers will increase growth rates and survival of exogenously feeding larvae and juveniles.	Lower basin propagation
Stocking with appropriate parentage and genetic diversity will result in increased survival of embryos, free embryos, exogenously feeding larvae, and juveniles.	

Jacobson et al. (2016a) defined several categories of hypotheses. Global hypotheses are a set of possible, biologically important hypotheses relevant to population dynamics that are derived from the CEMs. These were filtered by the pallid sturgeon effects analysis team to a set of 40 candidate dominant hypotheses that were identified by experts as being important in pallid sturgeon population dynamics. Through a series of workshops and a modified Delphi process, this list of candidate dominant hypotheses was filtered to 23 working dominant hypotheses. The working dominant hypotheses were meant to include plausible, biologically relevant hypotheses without regard to specific management actions. These working dominant hypotheses were then linked to management actions resulting in as many as 176 potential linkages, but when consolidated across life stages led to 53 hypotheses. The list was further reduced through an expert survey to 30 working management hypotheses. Finally, the set of working management hypotheses was filtered by USACE to eliminate actions that were not considered reasonable for the initial scope of implementation due to a current high degree of uncertainty in providing pallid sturgeon benefits, obvious severe effects on the human environment, and/or availability of other management actions that could potentially achieve the same objectives without the same level of uncertainty. This resulted in 21 management hypotheses (termed “initially modeled hypotheses” in Jacobson et al. 2016a). The decision to remove hypotheses from consideration was intended to focus efforts on modeling that would be relevant to decision-making for the scope of the initial proposed actions in this MRRMP-EIS. Any hypothesis that was removed at this step—or any other step in the process—is available later as needed to explain observed pallid sturgeon population changes (Jacobson et al. 2016a). Hypotheses that were not identified as management hypotheses fall into the hypothesis reserve (Jacobson et al. 2016a). All hypotheses developed during the effects analysis process and reserve hypotheses can be re-assessed through the AM process.

The management actions associated with the nine hypotheses eliminated by USACE and rationale for eliminating these hypotheses included:

- **Removal of Fort Peck Dam**: Section 2.5.2 discusses upper river pallid sturgeon management actions considered for plan alternatives and implementation within the 15-year timeframe covered by this MRRMP-EIS. Fort Peck Lake is the third largest USACE reservoir in the United States and drains 57,500 square miles (USACE 2006a). The USACE Master Manual states

  > Fort Peck's primary water management functions are (1) to capture the mountain and the plains snowmelt and localized rainfall runoffs from the large drainage area above Fort Peck Dam, which are then metered out at controlled release rates to meet the System's authorized purposes while reducing flood damages in the Fort Peck Dam to Lake Sakakawea reach; (2) to serve as a secondary storage location for water accumulated in the System from reduced System releases due to major downstream flood control regulation, thus helping to alleviate large reservoir level increases in Garrison, Oahe, and Fort Randall; and (3) to provide the extra water needed to meet all of the System's Congressionally authorized project purposes that draft storage during low-water years.

  Fort Peck is an important component of the System that contributes substantially to hydropower production, recreation, water supply, fish and wildlife, and flood control purposes. Congressional authorization would be required to remove Fort Peck dam. The rule of reason suggests that removal of Fort Peck dam would result in significant impacts to the human environment, many of which would be unacceptable to basin stakeholders and Tribes. USACE did not consider Fort Peck dam removal reasonable for consideration within the scope of this EIS because of the uncertainties regarding the effectiveness of this management action towards meeting pallid sturgeon objectives and the availability of other actions that would be less impactful.

- **Actions at Intake Dam and Cartersville Dam on Yellowstone River**: Section 2.5.2 discusses upper river pallid sturgeon management actions considered for plan alternatives and implementation within the 15-year timeframe covered by this MRRMP-EIS. Actions at Intake Dam were evaluated as part of a separate NEPA process evaluating various options for fish passage at Intake (Bureau of Reclamation and USACE 2016). Therefore, this hypothesis was not included within the scope of plan formulation for this EIS. The efficacy of any action at Cartersville dam relative to pallid sturgeon in the upper river is dependent on preceding actions being implemented at Intake Dam and documentation of successful fish passage at Intake. Therefore, consideration of actions at Cartersville Dam would be remote and speculative at this time.

- **Water Quality Management**: The contaminants hypothesis involved the regulation of agricultural runoff and municipal waste discharge to decrease exposure of endocrine-disrupting chemicals. Contaminants are listed as a potential threat to pallid sturgeon populations (Dryer and Sandvol 1993), and there is some evidence for contaminant exposure along the lower Missouri River (DeLonay et al. 2016). However, there are no definitive studies linking contaminants to reproductive failures or disease in the pallid sturgeon (DeLonay et al. 2016). A multi-agency effort is in the process of completing a review of this topic. As a result, USACE did not consider this a reasonable hypothesis to include in developing alternatives for the initial scope of actions to be taken under the Management Plan.

- **Platte River Flow Management**: The Platte River related hypothesis stated that naturalization of the flow regime on the Platte River would allow migration, spawning, and recruitment of pallid sturgeon to the Missouri River population. Tracking efforts since 2007 have documented four spawning events in the Platte River (DeLonay et al. 2016). Expert elicitation performed during the effects analysis identified a high degree of uncertainty associated with this hypothesis (Jacobson et al. 2016a). Given the high degree of uncertainty and availability of other management actions, USACE did not consider this a reasonable hypothesis to include in developing alternatives for the initial scope of actions to be taken under the MRRMP-EIS.

2.4 Models Supporting Alternatives Development

The modeling framework for the MRRMP-EIS involves the application of more than two dozen quantitative models. Several models were developed by the effects analysis team to inform the development of management actions and provide information regarding the effectiveness of these actions in achieving objectives. USACE developed hydrologic and hydraulic (H&H) modeling tools including Hydrologic Engineering Center (HEC) Reservoir System Simulation (HEC-ResSim) and River Analysis System (HEC-RAS) models. Outputs from both HEC-ResSim and HEC-RAS were used in effects analysis species modeling and in human considerations (HC) impacts models.

2.4.1 Hydrologic Engineering Center – Reservoir System Simulation Model

HEC-ResSim is a reservoir operations model developed by the USACE HEC. The model incorporates user defined rules with other conditions (i.e., inflow, pool elevation, and downstream flows) to determine reservoir outflow. The model also performs downstream hydrologic channel routing. Water managers, as well as water control manuals and other documentation, help in determining the rules necessary to simulate a reservoir within the model. The Missouri River Mainstem HEC-ResSim model was developed and used to simulate System operation of historical flows during an 82-year period of record (POR) (1931–2012). Flow-related management actions or alternatives that include altering reservoir operations were simulated and compared to a simulation of current operations to assess effectiveness towards meeting species objectives and the effects on natural, social, cultural, and economic resources of interest. HEC-ResSim simulations provided pool elevations and regulated inflows and outflows of each of the Mainstem projects for each alternative simulation. This data was used directly as input to impacts assessment models (i.e., HC models) and available HEC-RAS models that estimate inundation and discharges at locations on free-flowing reaches of the Missouri River.

The Missouri River Mainstem HEC-ResSim model was simulated using a daily time interval. The modeling includes the Mainstem Missouri River reservoirs and extends downstream to target gages on the lower river. The model contains all the rules needed for downstream operations: service level, navigation season length, flood constraints, water supply, etc., and calculates Gavins Point releases. Once Gavins Point releases have been calculated, the model sets releases for the other five reservoirs upstream of Gavins Point to balance System storage and keep the lower three reservoirs (Big Bend, Fort Randall, and Gavins Point), at their desired operating pool elevations. Several of the management actions and alternatives formulated for this MRRMP-EIS would require changes to current System operations. To assist in providing context for how the proposed alternatives would change current operation, Section 3.2, River Infrastructure and Hydrologic Processes, includes a summary of Mainstem System operations.

USACE's HEC Modeling Report (available online at www.moriverrecovery.org) describes the model in detail including scripted rules and an evaluation of model performance.

2.4.2 Hydrologic Engineering Center – River Analysis System Models

HEC-RAS is designed to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels. Common outputs include stage, duration/timing of inundation, water velocities, flow areas/routes, water temperature, and sediment loads. Unsteady flow analysis was chosen as the method of hydraulic modeling due to the need to analyze time series stage and flow data. Both the biological considerations (e.g., seasonal habitat requirements) and the HC (e.g., potential agricultural impacts) are affected by the timing of river flows. HEC-RAS was used to more accurately route discharges from reservoirs and tributaries to points downstream and to simulate impacts of mechanical changes in river channel geometry. These models simulate how proposed alternatives and management actions would impact river stage and discharge over a wide range of basin hydrologic conditions.

Five separate HEC-RAS models were developed for the Missouri River between Fort Peck Dam in Montana and the Mississippi River:

- **Fort Peck to Garrison Dam**: begins with the regulated outflow from Fort Peck Dam in Montana and extends approximately 382 miles downstream, to just upstream of Garrison Dam on Lake Sakakawea, North Dakota.
- **Garrison Dam to Oahe Dam**: begins with the regulated outflow from Garrison Dam in North Dakota and extends approximately 318 miles downstream to just upstream of Oahe Dam on Lake Oahe, South Dakota.
- **Fort Randall Dam to Gavins Point Dam**: begins with the regulated outflow from Fort Randall Dam in South Dakota and extends 69 miles downstream to just upstream of Gavins Point Dam on Lewis and Clark Lake.
- **Gavins Point Dam to Rulo, Nebraska**: begins with the regulated outflow from Gavins Point Dam in South Dakota at river mile (RM) 811.1 and extends approximately 313 miles downstream to Rulo, Nebraska, at RM 498.0.
- **Rulo, Nebraska to the mouth**: includes the lower 498-mile stretch contained within the boundary of the USACE Kansas City District as well as the Mississippi River between Grafton and St. Louis, Missouri.

The Oahe Dam to Big Bend Dam and Big Bend Dam to Fort Randall Dam reaches were not modeled in HEC-RAS due to the lack of riverine conditions between these dams.

The purpose of the HEC-RAS models was to create a baseline that closely represents current river conditions and to provide a tool to evaluate potential hydraulic changes resulting from proposed management actions or alternatives (e.g., channel reconfiguration and/or flow management). The baseline or existing conditions models were modified to represent a future condition under the No Action and action alternatives. Outputs of the HEC-RAS models were used in concert with other modeling programs such as HEC-Ecosystem Functions Model (HEC-EFM) and HEC-Flood Impact Analysis (HEC-FIA) to perform impacts analysis.

2.4.3 Bird Habitat/Population Modeling

The bird habitat/population models were used to evaluate the effectiveness of management actions and alternatives at meeting the bird objectives. The quantitative modeling framework for the bird species includes components for hydrology, riverine and reservoir shoreline habitat, and population viability. Buenau et al. (2016b) and Fischenich et al. (2014) document the models in detail. Hydrology and reservoir operations were modeled using HEC-ResSim, which routes basin runoff through the Missouri River using specified rules for reservoir operations. These rules were modified to reflect changes to reservoir operations under each alternative. The HEC-ResSim model used historical runoff and depletions from the POR as inputs and provided reservoir elevations, dam releases, and river stage at selected locations. Sequences of output years with randomly selected initial years were used in the habitat models.

Modeling of tern and plover populations as part of the effects analysis divided the river into northern and southern regions, with corresponding subpopulations for each. The northern region consists of Lake Sakakawea, Garrison river reach, and Lake Oahe; the southern region comprises Fort Randall river reach, Lewis and Clark Lake, and Gavins Point river reach. These two regions are notably different, with the north dominated by reservoir habitat and a single river reach, and the south consisting almost entirely of riverine habitat and tributaries. These regions are separated by a relatively large stretch of impounded river (Lake Francis Case and Lake Sharpe), which lacks breeding habitat and acts as a dispersal barrier, especially for piping plovers. Dispersal of both species between the northern and southern breeding areas occurs at a much lower rate than dispersal within those areas (Buenau et al. 2016b).

Emergent sandbar habitat (ESH) under varying flow conditions was predicted using a model that relates the deposition and erosion of sand to river flow and existing ESH area. At low flows, erosion rates are low. Erosion is greatest at moderate flows, then, as flows increase, deposition begins to occur (Fischenich et al. 2014). The amount of sand eroded or deposited and at what flows also depends on the existing ESH area. Models of ESH have been parameterized for each of three riverine reaches (Garrison, Fort Randall, and Gavins Point).

Reservoir shoreline habitat is modeled indirectly. Fledgling production on reservoir shorelines is a function of two hydrological metrics: the vertical extent of exposed shoreline that had been inundated for at least 160 days in the past 2 years and the increase in reservoir elevation during the nesting season. These metrics predict observed bird productivity better than habitat area, which is challenging to define and quantify on reservoir shorelines. The reservoir habitat-productivity modeling uses the daily time series of predicted reservoir elevations and bird population sizes on the reservoirs as inputs and output the number of fledglings produced.

Bird populations are modeled using viability models that account for the number of fledglings produced per pair of adults, annual survival for life stages (juvenile and adult plovers, juvenile, young adult, and older adult terns) and dispersal between river segments and regions. They use the output of the habitat models as inputs to produce fledge ratios (number of fledglings per pair of adults), population sizes, and associated population growth rates for each year and segment simulated. The population model for plovers is based upon Buenau et al. (2014c), updated to reflect the most current demographic rate estimates available (Buenau et al. 2016b).

The habitat and population models include uncertainty about parameter estimates. The population models also include demographic uncertainty (odds of individuals being born and surviving each year) and observation error. For any given scenario, models are run 5,000 times with random variables representing the uncertainty (using a Monte Carlo simulation methodology) and results are presented as metrics reflecting the distribution of results (e.g., median and confidence intervals).

2.4.4 Pallid Sturgeon 2-Dimensional Hydrodynamic Models

The effects analysis team developed 2-dimensional hydrodynamic models for pallid sturgeon functional habitat assessments to provide an understanding of how the availability of functional habitat varies with flow regime and channel reconfigurations (Jacobson et al. 2016b). These models were used to explore the effects of management actions related to changes in reservoir operations and channel reconfigurations on habitat availability in the lower river. The habitat models are based on the use of 2-dimensional hydrodynamic models of Deer Island (pre-construction) and Miami Bend as representative of channelized conditions and of Hamburg and Lisbon-Jameson bends as representative of best available conditions. These models are used to quantify the availability of food-producing and foraging habitats as a function of discharge.

2.4.5 Human Considerations Modeling

The term human considerations (HC) is used to address the interests of stakeholders and Tribes. These include the authorized purposes as well as the many other services afforded by the System. USACE and USFWS have worked closely with the Missouri River Recovery Implementation Committee (MRRIC) since January 2013 to identify the underlying stakeholder interests referred to as “human considerations.” HCs to be assessed when evaluating alternatives are rooted in the economic, social, and cultural values associated with the natural resources of the Missouri River. In January 2013, USACE asked MRRIC and their constituent stakeholders to provide input on the HCs relative to their use of the Missouri River and its resources. USACE requested this feedback to help inform how MRRIC collective interests could be considered in an assessment of consequences associated with management actions for the listed species. MRRIC formed the Human Considerations Ad Hoc Work Group as a mechanism to provide input on HC. The work group gathered and reviewed input from MRRIC members on the following categories: agriculture; commercial sand and gravel dredging; environmental conservation / fish and wildlife; flood risk management; irrigation; hydropower; local government; navigation; recreation; Tribal and cultural; water quality and water supply; thermal power; and wastewater. In August 2014, MRRIC made a consensus recommendation to USACE regarding HC objectives and performance metrics. This recommendation established criteria to ensure that adequate consideration is given to the possible interactions of management actions with human uses and interests on the river, and that these criteria are used to evaluate the impacts of alternatives in the MRRMP-EIS.

The MRRMP-EIS project delivery team (PDT) developed a suite of models for use in assessing the effects of management actions and alternatives to the HC. A subset of these models was used to calculate “proxy metrics” for the HC. Proxy metrics were used in the alternatives development process to inform discussions with MRRIC (Appendix A). Proxy metrics were capable of being efficiently modeled and calculated, responsive to changes in reservoir operations and/or channel geometry modifications, and indicative of the potential for impacts to a HC. In most cases, the proxy metrics assessment did not include the complete impacts analysis as presented in this EIS. Additional models (i.e., economic and habitat) were developed to facilitate impacts analysis of each alternative carried forward for detailed consideration in this EIS. These models were also the basis for calculation of National Economic Development (NED), Regional Economic Development (RED), Other Social Effects (OSE), and Environmental Quality (EQ) effects consistent with USACE planning requirements.

The models used to evaluate each HC are described in a series of technical reports available at www.moriverrecovery.org.

2.5 Management Actions

This section describes the general management actions that were considered during the alternatives development process. The range of management actions includes those that were directly linked to one of the management hypotheses documented in the effects analysis (Table 2-1 through Table 2-3). Management actions are presented based on applicability to the least tern and piping plover, pallid sturgeon in the upper Missouri River, and pallid sturgeon in the lower Missouri River. The discussion of each management action explains if the action was retained or eliminated from alternatives development with supporting rationale. A summary of management actions and if they were retained or eliminated is provided at the end of this section in Table 2-4. Effectiveness and efficiency were the primary criteria used in determining whether or not to eliminate a management action from further consideration at this step. Effectiveness refers to the extent to which the management action contributes to meeting the species objective. Efficiency refers to how cost-effective the management action would be at meeting the species objectives. It should be noted that eliminating a management action from further consideration for the alternatives in this EIS does not exclude the action from being the subject of further research or study as part of the Science and Adaptive Management Plan (SAMP).

2.5.1 Least Tern and Piping Plover

The following management actions were considered in developing alternatives to avoid a finding of jeopardy to the least tern and piping plover from USACE actions on the Missouri River. The management action descriptions are largely taken from Buenau et al. (2016b).

2.5.1.1 Emergent Sandbar Habitat Creating Flow Release

Flows that are high relative to the elevation of existing sandbars have the potential to mobilize and deposit sediment at high enough elevations to create new sandbars when water levels recede (Buenau et al. 2016b). High flows must be of sufficient duration to build sandbars to a high enough level to provide suitable habitat at more typical flows. The amount of habitat created depends on the magnitude and duration of the flow release and the area of sandbar present prior to the release (i.e., ambient ESH). This management action would consist of a deliberate reservoir release of flows in either the spring (March through May) or fall (October through December) for the purpose of creating ESH. Habitat-forming flow releases can be combined with all other least tern and piping plover management actions; however, timing is a consideration. For example, a habitat-forming flow release would not be planned to overlap with mechanical ESH construction within any year because the effectiveness of the flow release would be reduced. This action was retained for alternatives formulation and was the subject of several iterations of modeling and alternative formulation described in Section 2.7, Bird Alternatives Development.

2.5.1.2 Mechanical Habitat Construction on River

Mechanical ESH construction includes any activity that constructs in-river habitat without the use of flows. USACE has an existing ESH Program and has constructed ESH in the Gavins Point river reach and upper Lewis and Clark Lake from 2004 to 2010. The ESH Program is currently implemented in compliance with the 2003 Amended BiOp (USFWS 2003) and as specified in the Record of Decision (ROD) for the *Programmatic Environmental Impact Statement for the Mechanical and Artificial Creation and Maintenance of Emergent Sandbar Habitat in the Riverine Segments of the Upper Missouri River* (USACE 2011). The MRRMP-EIS ROD will replace the ROD written for the ESH PEIS in 2011; however, this will not invalidate analyses and tools developed during the previous effort.

Methodologies used for construction of sandbars vary by each project site. The selected contractor is allowed some freedom to choose their preferred construction methodology. Various combinations of dredging and/or heavy equipment such as backhoes, draglines, bulldozers, and scrapers are used to construct the sandbar to specified contours and elevations. The construction season for ESH projects is short— limited to the times of year when least terns and piping plovers are absent and weather conditions allow. These species typically arrive in mid-April and leave in mid to late August. The ESH Program has contractors ready to begin work as soon as the birds leave the area in late summer and work continues until the area exhibits ice conditions. Construction may not occur in the Missouri National Recreational River segments until after Labor Day. National Park Service (NPS) coordination requirements regarding construction of ESH in the Missouri National Recreational River segment is discussed further in Chapter 6. Figure 2-3 is an example of a constructed sandbar.

Figure 2-3. Example of a Constructed Sandbar

ESH sites are chosen by a multi-agency team using a number of selection criteria. One of the main selection criteria is a site where USACE can capitalize on an existing shallowly submerged sandbar by raising it to exposed elevations. The programmatic implementation of ESH to date is based on a principle of systematic avoidance of potentially sensitive resources and the de-selection of less suitable sites. This management concept was documented in the ESH PEIS and would continue to be associated with ESH construction under each of the alternatives. Sensitive resources are defined as known locations of protected plant and animal species, heritage and cultural resources, public and private infrastructure features, existing public and private recreational features, and other elements of the human environment. This is accomplished through site-specific NEPA analysis that includes identification of the potential presence of sensitive resources and coordination with the Tribes, public, stakeholders, and resource agencies prior to start of construction. USACE also would continue to conduct testing of materials used in construction (e.g., sand) for contaminants prior to using them for in-river ESH construction.

Mechanical ESH construction was retained for further alternatives development and could occur in the following river reaches:

- Garrison Reach: riverine segment between Garrison Dam and Lake Oahe; RM 1389.9-1304
- Fort Randall Reach: riverine segment between Fort Randall Dam and Lewis and Clark Lake; RM 880-845
- Gavins Point Reach: riverine segment below Gavins Point Dam and above the channelized river beginning at Ponca, Nebraska; RM 811.1-754

2.5.1.3 Mechanical Habitat Construction on Reservoir Shorelines or Islands

Mechanical habitat construction on reservoirs was proposed to provide higher-elevation nesting habitat for high-flow years when riverine habitat and lower-elevation reservoir shoreline habitat are unavailable. Reservoir habitat was included in "off-channel" habitat recommendations made by MRRIC. Created reservoir habitat would require intensive maintenance to keep vegetation from establishing. It would also likely require intensive predator control if birds use it for nesting for multiple years. There is also uncertainty as to whether or not birds would be attracted to this habitat.

USACE (2014a) recommends that the priority for mechanical habitat construction efforts should remain focused on the current riverine construction efforts, and not in the reservoirs. This conclusion was based on the identification of multiple uncertainties and risks, including inundation, increased incidental take, excessive cost compared to other proven habitat construction options, infrequent availability for use by the birds, and potential increases in predation and maintenance. Per acre project costs ranged from $60,000 for a large project, which could benefit from economies of scale, to $230,000 for smaller projects in the Mainstem reservoirs (USACE 2014a). Average per acre cost for Mainstem reservoir projects was $172,000 (USACE 2014a) compared to $50,000 per acre for in-river habitat construction (estimate developed for this EIS). USFWS also recommended not including this action as part of the plan citing the need for better understanding of reservoir habitat dynamics in relation to bird densities and reproductive success (USFWS 2015a). USFWS (2015a) stated that since monitoring of least tern and piping plover populations within the Missouri River began in 1986, approximately 80 percent of the total incidental loss/mortality of piping plover eggs and chicks and 58 percent of least tern eggs and chicks were due to rising pool levels in reservoirs. Therefore, this management action was eliminated from further consideration because its effectiveness at meeting species objectives is not currently demonstrated relative to other available management actions. As described, it is also inefficient at meeting species objectives based on project costs relative to other available management actions.

2.5.1.4 "Off-Channel" Habitat Creation/Mechanical Creation of Hydrologically Connected non-ESH Habitat on River Segments

The MRRP Independent Science Advisory Panel's (ISAP's) evaluation of the Draft Bird Adaptive Management Cycle Example (ISAP 2015) contained recommendations to consider "off-channel" habitat for the birds as a management action. Additionally, on several occasions since 2010, MRRIC has recommended consideration of "off-channel" nesting habitat as a management action. These discussions have included habitat within reservoir pools, off-channel habitat similar to sandpits adjacent to the central Platte River and habitat creation in the navigation channel below Ponca, Nebraska (USFWS 2015a). The reservoir habitat component was discussed in Section 2.5.1.3; however, the other two components are considered here.

USFWS defines “off-channel” habitat as areas that are not connected to the main channel hydrologically, energetically, and/or through sediment degradation/aggradation processes (USFWS 2015a). USACE completed an initial assessment of off-channel habitat creation opportunities (USACE 2012a). The following sites were included in that assessment:

- Platte River Sandpits: Kearney, Nebraska, and vicinity
- Sandpits Adjacent to the Missouri River: North Dakota, South Dakota, and Nebraska
- Audubon Bend and North Alabama Bend: Wynot, Nebraska, and Vermillion, South Dakota
- Off Reservoir Within USACE Boundary Sites: Lake Sakakawea, North Dakota
- Audubon National Wildlife Refuge: Cole Harbor, North Dakota
- Lake Sharpe, South Dakota
- I-29 Borrow Pits: various sites in Iowa
- Kensler’s Bend: Nebraska and South Dakota
- DeSoto Bend National Wildlife Refuge: Missouri Valley, Iowa

The report identified some of these sites as having potential for consideration or further study as pilot projects. The report identified drawbacks associated with each site, which generally included land ownership considerations, extensive vegetation and predator management, and construction considerations (e.g., the need to haul sand to site and excavation requirements).

The USFWS definition would only apply to the sandpit or borrow pit sites listed; however, habitat creation in the BSNP reach of the Missouri River below Ponca, Nebraska is also considered in this section. USFWS recommended that USACE not include sandpit habitat management or habitat development in the BSNP reach as management actions in this plan (USFWS 2015a). USFWS identified several issues that would need to be resolved to consider this a feasible management action including the reproductive potential of these areas, potential for high predation, habitat preferences and dispersal, forage availability, land acquisition, and feasibility of creation and maintenance (USFWS 2015a). This management action was eliminated from further consideration because it is not currently demonstrated to be as effective or efficient at meeting species objectives relative to other available management actions such as in-river mechanical ESH construction and vegetation management on ESH (USACE 2012a). Although this action was eliminated from consideration in this EIS, USFWS has expressed to MRRIC a willingness to pursue funding for a pilot project. This funding would not be through USACE’s MRRP; however, the results of any pilot project could be evaluated under the SAMP.

2.5.1.5 Modification or Augmentation of Existing Sandbars

Sandbars can be augmented using dredges and earth-moving equipment to add sand to existing bars. Sandbars can also be reshaped to lessen the effects of erosion such as cut banks that limit the availability of foraging habitat. Many similarities exist between the mechanical construction of sandbars and the augmentation of existing sandbars, although costs and other logistics differ. Modification and augmentation of existing sandbars typically require less time and budget than construction of new ESH. This action was retained for alternatives development; however, the impacts of this action are considered to be included under the impacts of mechanical ESH construction because they affect resources similarly.

2.5.1.6 Vegetation Management

Vegetation growth on sandbars may limit the amount of suitable nesting habitat available to plovers and terns. USFWS lists vegetation encroachment as a major factor in limiting the amount of suitable nesting habitat for piping plovers in the Piping Plover 5-year Status Review (USFWS 2009). Sandbars are generally selected for vegetation control and removal due to historical use as nesting habitat by least terns or piping plovers. The primary and preferred method of vegetation control and removal is application of pre- and/or post-emergent herbicides. Herbicides may be applied by spraying from all-terrain vehicles or by hand in smaller, less vegetated areas. Less often, herbicides may be sprayed from the air in large, densely vegetated areas. Additional vegetation control and removal methods include cutting, mulching, disking, mowing, raking, and removing vegetation from sandbars. Post-treatment removal using these additional methods may be necessary depending on the height and density of the vegetation. Vegetation that is woody with large stems may need post treatment breakdown and removal.

Vegetation management strategy is to treat vegetation during its first year of growth and follow up with maintenance spraying. Duration and intensity of the initial treatment and removal depends upon the size and density of the vegetation on the sandbar. Maintenance spraying is done on an annual basis to control any vegetation that emerges after the initial removal/spraying efforts which minimizes the need for mechanical removal of vegetation. In cases where vegetation is very thick, such as stands of Phragmites, it is often more effective and less expensive to use controlled burns. In cases where woody vegetation has established, mechanical removal activities are often necessary, but areas where extensive mechanical removal of vegetation is necessary are mostly avoided because of cost and efficiency.

If mechanical removal is undertaken, the preferred methods of removal, in terms of efficiency are, 1) mowing, 2) mulching, 3) cutting. Mowing is typically used when stem diameters are less than an inch. For larger stems, mulching tends to be more effective. For very large stems with low abundance, cutting may be the preferred method. Typically, the first step is to apply the herbicide on the vegetation, which is absorbed by the plant roots, stems, or leaves. Once the herbicide has taken effect and the vegetation dies off, any standing dead woody debris would be removed using one of the aforementioned methods. Past results have indicated that removal without prior herbicide treatment of the vegetation often leads to a quick return of even thicker vegetation. A compact track loader along with a mowing, mulching, or cutting attachment is typically used to clear the sandbars of remaining dead vegetation.

Due to the variability in duration and intensity of vegetation control and removal, costs are variable as well. Initial costs have the potential to be more expensive than the annual maintenance if sandbars require spraying and post treatment removal. Annual maintenance costs using herbicide amount to roughly $100 per acre treated. In general, prescribed fires have run $65/acre. For mechanical removal, the most recent efforts have averaged roughly $500/acre although numbers can vary greatly depending on terrain, vegetation types, and other logistical issues.

To address water quality concerns, USACE collects samples and analyzes for Glyphosate, AMPA, and Imazapyr, which are the typical herbicides used for controlling vegetation on sandbars. Water quality monitoring is assumed to continue in association with the vegetation management action under all alternatives in this EIS. Vegetation management was retained for alternatives development. This action would need to be implemented in combination with other habitat-creating management actions. It would not be effective on its own at meeting species objectives, but can enhance the effectiveness of other management actions and natural ESH creating flow events by extending the suitability of existing ESH.

2.5.1.7 Habitat Conditioning Flows

Habitat conditioning flows are reservoir releases of a specific magnitude and duration intended to maintain existing ESH. These flows overtop existing sandbars but are not high enough or of long enough duration to form new sandbars. These conditioning flows may scour existing vegetation, prevent establishment of woody vegetation, and deposit new sand on existing sandbars. These deposits enhance the quality of existing ESH and in turn increase the area of nesting/brood-rearing habitat. The overall improvement to an ESH area resulting from habitat conditioning flows remains uncertain because these flows may also erode existing sandbars. The characteristics of habitat condition flows (i.e., magnitude and duration) would be variable from year to year. Implementation of habitat conditioning flows was eliminated from further consideration within the scope of the MRRMP-EIS because there is not enough information at this time to indicate this action would be effective or efficient relative to other management actions. Further research on the potential of this management action would be considered under the SAMP.

2.5.1.8 Reservoir Water Level Management

Reservoir water level management involves the intentional manipulation of reservoir levels to increase the availability of nesting and brood-rearing habitat for the bird species. Reservoir releases expose potential shoreline habitat. Exposed shorelines that were previously inundated for more than 160 days in the past 2 years are expected to increase the unvegetated area available for nesting. Increases in reservoir elevation during the nesting season can inundate nests and lower fledgling production on reservoir shorelines. Such increases commonly occur as part of routine operations, particularly in Lake Sakakawea. In contrast, stable or declining reservoir levels during the nesting season can reduce or prevent nest inundation and provide additional foraging habitat. Only Lake Sakakawea and Lake Oahe have sufficient potential habitat (i.e., gradually sloping shorelines and areas free of bluffs) and water level variation to provide reservoir habitat. This management action was retained for alternatives development.

2.5.1.9 Lowered Nesting Season Flows

Lowered nesting season flows would consist of the intentional reduction of reservoir releases from standard releases during the May to August timeframe. Lowered nesting season flows may benefit least tern and piping plover in two ways: (1) the lower water surface elevation exposes more ESH for nesting, brood-rearing, and foraging and (2) the reduced flow can potentially decrease the rate of erosion of existing ESH. River stage during the nesting season determines how much habitat is available for nest site selection, brood rearing, and foraging. In nearly all cases, low flows expose more habitat that birds can use (eroded cut banks on sandbars may limit the extent to which more habitat becomes available, and whether piping plover chicks have access to foraging habitat). Generally, any decrease in flow would increase habitat availability on river reaches; however, there is not a specific discharge that would have the same magnitude of effect in all cases. The resulting increase in habitat depends on how much ESH is in the river and at what elevations; if very few sandbars are present, less potential habitat is available to be exposed by low flows. Reducing reservoir releases to achieve a lowered nesting season flow would increase reservoir levels, which has potential to affect birds nesting on reservoir shoreline. A lowered nesting season flow may also necessitate higher flows later in the year to evacuate flood storage in the reservoirs, which has the potential to increase the rate of ESH erosion. This management action was retained for alternatives development.

2.5.1.10 Flow Management to Reduce Take

In general, releases from Gavins Point are adjusted as needed to meet target flow levels on the lower Missouri River, taking advantage of downstream tributary runoff. However, during the nesting season of the least tern and the piping plover, care must be taken to avoid impacts to nesting areas. Several scenarios have been used in past years to regulate the System during the nesting season. Under the steady release scenario, when the birds begin to initiate nesting activities in early to mid-May, the release from Gavins Point is set to the level expected to meet downstream flow targets for navigation on the lower Missouri River through August and maintained at that level until the end of the nesting season. This regulation results in releases that exceed the amount necessary to meet downstream flow targets during the early portion of the nesting season, and may result in downstream flow targets being missed if basin conditions are drier than expected during the summer. The term "navigation season" refers to the period when flow support is being provided from the Mainstem reservoirs to serve navigation on the lower Missouri River.

Gavins Point releases under the flow-to-target scenario are adjusted as needed throughout the nesting season to meet downstream flow targets and would typically result in increasing releases as the nesting season progresses. This is due to reduced tributary inflows downstream as summer heat builds, evaporation increases, and precipitation wanes. Increasing releases as the nesting season progresses has the potential to inundate nests and chicks on low-lying ESH. Compared to the steady release scenario, this scenario conserves more water in the System, which keeps the upper three reservoirs at relatively higher levels. However, this scenario also increases the risk of inundating nests. The flow-to-target scenario also ensures that targets on the lower river are met throughout the nesting season.

A third scenario for Gavins Point releases combines features of the other two options. This scenario, called the steady release - flow-to-target scenario, sets Gavins Point releases at an initial steady rate and then allows releases to be adjusted upward or downward during the nesting season to meet downstream flow targets, if necessary. Depending on the rate of the initial steady release, this regulation makes a larger amount of habitat available downstream of Gavins Point early in the nesting season and saves additional water in the upper three reservoirs when compared to the steady release scenario. The steady release - flow-to-target scenario also reduces the potential for flooding nests when compared to the flow-to-target scenario. The steady release - flow-to-target regulation also provides certainty for downstream users that releases could be increased if needed to meet Missouri River flow targets.

Under each of these scenarios, releases from Gavins Point may be increased every third day to encourage terns and plovers to build their nests on higher habitat so nests would not be inundated later when higher releases are required to meet the regulation objectives of the System. This pattern of increasing releases every third day is referred to as “cycling.” Cycling is generally not used during years when System storage is high but has been used during extended drought, when water conservation is important. Cycling is suspended when chicks hatch to reduce the risk of stranding chicks on low-lying sandbars. Unfledged chicks can be lost if stranded on low-lying sandbars that are subsequently inundated. Depending on the hydrological conditions, scenarios mentioned above would remain once cycling is suspended. Cycling of Gavins Point when releases are reduced for downstream flood control during the nesting season has also been used to keep birds nesting at sufficiently high elevations to maintain room for release increases when downstream flooding has subsided. The daily variation in releases is normally limited to 8,000 cubic feet per second (cfs) to minimize adverse effects on downstream river users and fish.

Depending on the hydrologic conditions in any given year, Garrison daily average releases may be set lower in July and part of August to increase rearing and foraging habitat. This action will also provide freeboard for nests that have not hatched. In addition, the peaking pattern at Garrison and Fort Randall may be reduced during the nesting season to minimize take. Fort Randall releases typically follow Gavins Point releases minus the intervening incremental flow. This management action was retained for alternatives development.

2.5.1.11 Predator Management (Predator Removal and Nest Caging)

USACE has been implementing this management action under a Predation Management Plan (USACE 2009a) developed in compliance with the 2003 Amended BiOp (USFWS 2003). The area subject to predator management activities includes all segments of the river where USACE currently monitors and manages for piping plover and least tern productivity. The primary objective of the plan is to increase the productivity of least terns and piping plovers by reducing the loss of eggs and chicks to predation and reducing the number of adults that are predated or driven away from nesting areas due to disturbance by predator species. The plan describes control methods to be employed to reduce predation, and provides a framework of guidelines for the implementation of predation control actions. The plan also provides a process for the evaluation of the effectiveness of predator management in achieving objectives.

The number of eggs and chicks lost to predation can be reduced or limited through either direct or indirect predator control and management actions. Predator control and management actions are implemented based on monitoring of least tern and piping plover breeding sites throughout the breeding season. Management actions are taken when there is observed predation activity impacting the success of least tern and piping plover breeding pairs. The level of action taken is based on habitat availability and severity of predation occurring. When habitat is abundant, the evidence of predation is less noticeable and fewer predator management actions are taken. When habitat is less abundant and signs of predation more evident, actions to manage predators are taken more often.

Direct management actions include the lethal or non-lethal removal of predators and are typically deployed when habitat is limited and the level of predation is high. Targeted species such as raccoons, coyotes, mink, and great horned owls are either lethally or non-lethally removed depending on the species and situation. Typically, state and federal wildlife control specialists are responsible for the non-lethal and lethal removal activities of targeted species.

Indirect management actions may include caging or fencing breeding sites (e.g., nests or groups of nests), or hazing, which dissuades predators from breeding sites and are deployed when predation activities are present but not severe. Plover nests at risk of predation are primarily protected by placing exclosure cages around them. Exclosure cages can only be used to protect plover nests; terns frequently fly to and from their nests and are less likely to walk through the enclosure.

All predation control activities are conducted in compliance with all applicable state and federal regulations. Although cost estimates for predator management and control vary depending on level of effort required, past contracts with state and federal wildlife specialists ranged from $10,000 to $50,000 annually. These contracts involved intensive predation control efforts when habitat levels were low, and tern and plover nest densities and predations rates were high. All predation impacts observed and predation control activities undertaken in the field during the bird monitoring season are documented. This management action was retained for alternatives development.

2.5.1.12 Human Restriction Measures

Throughout the least tern and piping plover breeding season there is the possibility of interaction between birds and people. This can range from innocent curiosity to deliberate destruction of nests or eggs. Several measures can be taken to reduce disturbance to the birds. Posting signs that restrict access to breeding areas, placing barricades to exclude human access, and outreach efforts are all frequently deployed actions that help to control and restrict human disturbance to breeding sites.

Barricades are more often used to prevent vehicular access to nesting sites located along reservoir shorelines and are most commonly placed next to recreation areas to prevent off-road vehicle access to beaches. Barricades can be constructed using natural features such as rocks and logs, or a fence with a gate as a more permanent deterrent. When the birds have completed their nesting and chicks have fledged and left the site, the barricades and signs may be removed.

Endangered species restriction signs are placed at specific locations to make the public aware of least tern and piping plover nesting areas as well as the potential for prosecution of those individuals that enter a posted site under the ESA. Placement of restriction signs is evaluated on a case-by-case basis and depends on both the level of use as well as the level of bird activity. Sites that are remote with little opportunity for human disturbance may not be marked with restriction signs, as signs might attract people to the site out of curiosity. Generally, under best practices, all river sites that contain five or more nests should be posted with restriction signs. All reservoir sites that have the potential for human visitation, especially those adjacent to recreation areas should also be posted. Restriction signs should be placed so that they are visible to the public at all entry points to nesting areas. On sandbar and beach shorelines, the signs are placed near the water to forestall boaters from landing. When the birds have completed both nesting and chick rearing, and have left a site, the restriction signs are removed.

Human deterrence measures also include information sharing and education. These measures may be demonstrated by having one-on-one conversations with individuals at boat ramps, handing out endangered species informational materials, giving campground talks, posting endangered species information signs, and giving public service broadcasts via television and radio. This management action was retained for alternatives development.

2.5.1.13 Channel Modifications to Increase Width

Channel width has been associated with the formation and persistence of sandbars, in that sandbars are more likely to form and persist where the channel is wider. Although widening a channel would not inherently create more nesting habitat, it may improve conditions for sandbars to form under high flows and could reduce erosion on existing sandbars. Buenau et al. (2016b) summarized the lines of evidence leading to consideration of this management action.

However, this action was eliminated from further consideration because at this point there is a great deal of uncertainty about the scale of widening needed to increase persistence and/or formation of sandbars and there are other management actions available to achieve the objectives that are not associated with the same level of uncertainty and risk. This management action will be further investigated through habitat monitoring and modeling through the SAMP.

2.5.1.14 Sediment Redistribution

Sediment redistribution generally involves transporting sediment from reservoirs to the river reach downstream of the dam. The intent of redistribution would be to increase the sediment supply for sandbar formation in the downstream river reach, thus increasing the amount of ESH created by higher flows. The Lewis and Clark Lake Sediment Management Study is investigating the engineering viability of this management action. Modeling completed to date has evaluated the hydraulic transport of Lewis and Clark Lake delta sediments through Gavins Point dam via sediment flushing (USACE 2013). The assessment considers all of the sediment deposited in the reservoir, including sand, silt and clay fractions derived from both the Niobrara River and the reach of the Missouri River between the delta and Ft. Randall Dam. Five flushing scenarios—focused on very high river flows over a short duration—were developed as part of Phase I of this study. Modeled flows varied from 88,000 cfs to 176,000 cfs with up to 7 days at the peak flow. The largest event was also simulated with a section of the Gavins Point Dam spillway lowered by 10 feet to increase the energy available to move sediment. All flows in these simulations were released through the spillway at Gavins Point Dam to avoid sending sediment flow through the powerhouse. All the scenarios included draining Lewis and Clark Lake, increasing discharge upstream at Fort Randall Dam to the peak flow, maintaining the flow for the flush duration, and a reduction in flow that coincides with reservoir refilling.

The USACE model showed that all the flushing scenarios predicted the transport of silt and clay sized particles through the dam. In the cases of high flow and modified spillway, the model predicted very high sediment concentrations and total mass of sediment transported. Sands flushed from the delta redeposited in the reservoir further downstream. Due to the length of the reservoir and the location of the spillway gates 20 feet above the lake bottom, almost no sand was passed through the spillway for any scenario. Only the flushing scenario with 176,000 cfs and the modified spillway gates, when sediment concentrations were the highest, predicted 0.07 percent of the mass of sediment passing the spillway as sand; the remaining 99.93 percent was silt and clay. This result is important because the delivery of sand would be needed to support sandbar habitat development below the dam.

The spillway crest elevation above the reservoir bottom prevents complete draining of the reservoir through the spillway, resulting in a sediment trap at the face of the dam. The study concluded that additional scenarios exist that warrant additional examination. These additional scenarios along with an evaluation of cost considerations are included in Phase II of this study, which is ongoing. Repeated flushing events may result in better sediment transport to the downstream channel once deeper areas of the lake are filled in. Similarly, some flushing scenarios coupled with infrastructure changes may prove more effective as the delta fronts move closer to the dam over time. A pipeline slurry option was considered, but the cost estimates (~$40 million/year) made that option prohibitive. Initial cost estimates for dredging Lewis and Clark Lake indicated the least expensive solution was approximately $10/yd to deliver to the downstream channel, and the lake fills with approximately 4 million cubic yards annually. This translates to approximately $40 million annually plus capitol startup costs. Some concepts involving “channelization” of the reservoir sediments to improve transport efficiency were developed and may be investigated further in the future. This action was eliminated from further consideration in this EIS because its effectiveness at contributing towards species objectives and implementation feasibility has not been demonstrated to date. Further research on the potential of this management action would be considered under the SAMP.

2.5.2 Upper River Pallid Sturgeon

The following management actions were considered in developing alternatives to avoid a finding of jeopardy to the pallid sturgeon in the upper Missouri River from USACE actions on the Missouri River.

2.5.2.1 Fort Peck Actions/Lake Sakakawea Drawdown

The effectiveness and technical feasibility of management actions for achieving pallid sturgeon objectives in the upper Missouri River are highly dependent on several physical and environmental constraints and remaining critical uncertainties related to pallid sturgeon behavior. The effects of available drift/dispersal distance and hypothesized inhospitable headwaters of Lake Sakakawea pose distinct constraints on pallid sturgeon recruitment. The ability to overcome these constraints may depend on the efficacy of the following management actions:

- Altering the flow regime at Fort Peck,
- Temperature control at Fort Peck,
- Sediment bypass at Fort Peck, and
- Drawdown of Lake Sakakawea at Garrison Dam.

> ***Drift**: Drift is the passive dispersal of drifting embryos carried by the flow of river water from the site of hatching to rearing habitats as fish mature and become more stationary.*

Because the natural upstream migrations of spawning adult pallid sturgeon are blocked by Fort Peck Dam and severely limited by Intake Diversion Dam on the Yellowstone River, available main channel drift distance for drifting sturgeon embryos is reduced (Figure 2-4). Lake Sakakawea is currently considered to be an impediment to larval pallid sturgeon survival because evidence of anoxic (i.e., no oxygen) conditions in the transitional zone of Lake Sakakawea suggest that free embryos settling in that zone would not survive (Bramblett and Scholl 2018). The anoxic condition at Lake Sakakawea effectively reduces habitat necessary for wild pallid sturgeon larvae to complete their drifting transition from free embryo to larvae to the free-flowing riverine sections upstream of the Lake Sakakawea pool. During late 2017, an article was published that challenged the hypothesis that pallid sturgeon recruitment is primarily limited by drift distance (Marotz and Lorang 2017). The article is based on depth and velocity data collected with acoustic Doppler current profilers concurrent with the 2016 Upper Missouri drift experiment, coupled with a novel particle-tracking scheme. The article makes essentially two arguments. The first argument is that because the free embryos are transported dominantly near the bed where velocities are inherently lower, their drift rate is much slower than previously estimated. The second assertion is based on the authors' proprietary particle-tracking model which predicts frequent "stalls" of particles when interpolated velocity vectors encounter islands or river banks. The result is that most of the particles (free embryos) that might start at the Milk River confluence are predicted to be retained in the Upper Missouri River; the few that make it to Lake Sakakawea without stalling would require as much as 30 days. The authors therefore ascribe lack of recruitment to processes other than drift distance limitation, such as predation or lack of food resource. Although the article addresses critical assumptions of drift processes that have been identified by previous authors as needing additional research (Braaten et al. 2008; Fischenich et al. 2014; Jacobson et al. 2016a; Fischenich et al. 2017), the methods apparently have received minimal review to date. A robust, critical review process would be needed to evaluate the Marotz and Lorang (2017) results for applicability to the MRRP decision process.

Available data from a past drift experiment indicate that hatchery-released free embryos, 5 days post-hatch or older, are able to survive to age-1 in the Missouri River between Fort Peck Dam and Lake Sakakawea, when released 170 miles upstream of the lake (Braaten et al. 2008). Natural recruitment has not occurred in this reach, however, suggesting that mortality may occur due to insufficient drift distances to support the transition from a drifting free embryo to a settled, benthic feeding larvae. These observations support the hypothesis by Kynard et al. (2007) which implicates total drift distance as a limitation on natural recruitment. Thus, within a given river reach, the distance required to complete the early life stage requirements is dependent on total reach length (based on available river length and spawning site selection), flow conditions, (river discharge and velocity), habitat complexity and quality, and temperature; all of which influence the Missouri and Yellowstone rivers differently.

The Missouri River between Fort Peck Dam, Montana, and the headwaters of Lake Sakakawea, North Dakota is regulated by releases from Fort Peck Dam, ultimately affecting water temperature, spawning cues, side-channel inundation, and habitat-forming processes. Overall, this reach is approximately 211 miles (340 kilometers [km]) in length. Considering the effects of the deep, cold water discharge from Fort Peck Dam it is reasonable to conclude that the first 24–31 miles (40–50 km) downstream of the dam is unsuitable for pallid sturgeon spawning due in part, to cold water temperatures (Braaten et al. 2012), unless water temperature is mediated by inflows from the Milk River, releases over the Fort Peck Dam spillway, or through a temperature-control mechanism. Therefore, riverine habitat available for the larval drift transition to occur in this river reach is limited to only 180–186 miles (290–300 km) under typical conditions without spillway releases. The available drift distance within this reach is at the very lower end of what is believed necessary. Settlement of drifting free embryos generally occurs about 8 to 14 days post hatch depending on temperature (Braaten et al. 2012). The actual amount of time spent drifting could be less than that if the fish reside in the small spaces within the substrate for some period following hatch. Recent laboratory investigations (DeLonay et al. 2015) cast doubt on any “interstitial hiding” behavior by newly hatched pallid sturgeon and supports hypotheses of immediate drift, although lack of residency has not been established for all potential combinations of field conditions (Jacobson et al. 2016b).

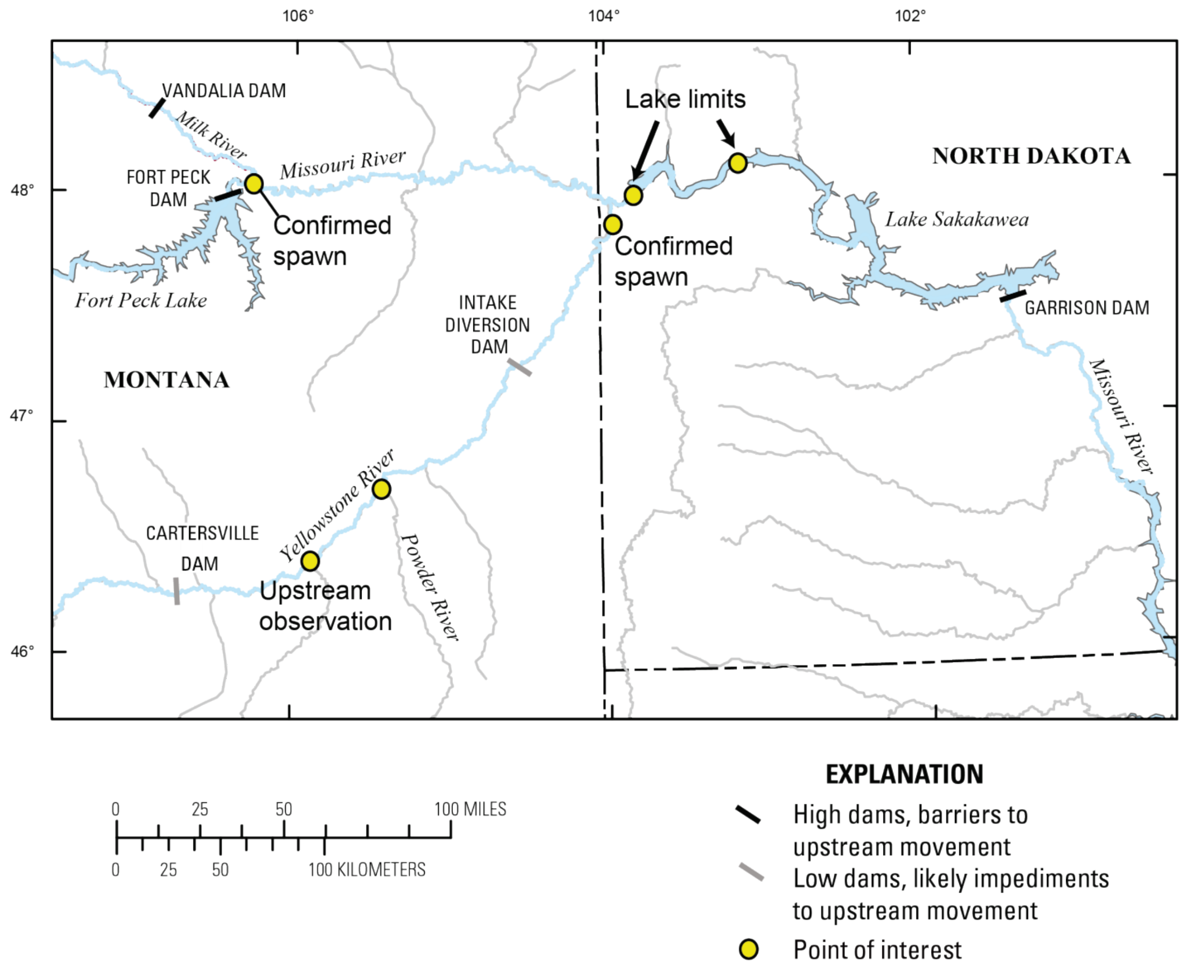

Figure 2-4. Upper Missouri River Locations Influencing Drift Distance Availability

The effects analysis (Fischenich et al. 2014) applied advection/dispersion modeling to assess drift in the Fort Peck to Lake Sakakawea reach. In one set of analyses they replicated flows and pool levels in a 10-year period from 2003 to 2012 to determine what percentage of free embryos remained within lotic reaches (i.e., upstream of the reservoir transition zone) for various drift durations. The model assumed spawning occurred at the Milk River confluence, about 9 miles downstream of the dam, where spawning was inferred in 2011 when extraordinary flows attracted an aggregation of reproductive fish relatively far upstream. The model predicted that 70 percent of the embryos remained in riverine segments on average after 6 days over the 10-year period. That figure dropped to 45 percent after 7 days, 16 percent after 8 days, 4 percent after 9 days, and only 0.5 percent at 10 days of drift. Considered on an annual basis (rather than an average), half the years exhibited more than 20 percent retention after 8 days of drift and more than 4 percent after 9 days (but zero or nearly zero in the remaining half after just 8 days). A larval drift experiment in 2016 involved release of nearly 700,000 1- to 2-day post hatch larvae near the confluence of the Milk River. Although recovery of free embryos was low, physical data collected to support the experiment validated predictions from the advection/dispersion model (Erwin 2017). Nevertheless, one of the release experiment individuals was captured in the Missouri River near the Yellowstone confluence in August 2017 and identified based on its unique genetics. This capture confirms that the probability that a drifting free embryo spawned near the Milk River can survive in the Upper Missouri River is greater than zero.

The effects analysis also modeled a wide range of conditions to assess the efficacy of management actions. It directly considered the effectiveness of decreased flows to reduce advection (i.e., alteration of the flow regime at Fort Peck) and lowered pool levels (i.e., drawdown) in Lake Sakakawea to extend the riverine segment. The Fort Peck temperature control action can be assessed with the model results using drift duration as a surrogate for temperature. Developmental data indicate that an increase in water temperature by 4°C could increase the rate of embryo development thereby decreasing the time spent in drift by 4 days. Simulations of drift were made using advection/dispersion models with an assumed spawning location at the Milk River confluence, as previously described. Simulations were made using flows ranging from 3,000 to 18,100 cfs (the historic minimum to the 5 percent exceedance level), and pool elevations in Lake Sakakawea from 1,805 feet msl to 1,856 feet msl (approximately the range of observed values in the past 50 years), including the historic minimum, recent minimum, and maximum levels as well as the median and 10 and 90 percent exceedance values. In all, 48 combinations of flow and pool level were modeled and the percentage of free embryos retained in lotic reaches documented at 2-day intervals from 2 to 12 days of drift. These analyses demonstrate that all three management actions affect retention, as does the degree of dispersion, which was adjusted as an additional model variable. They also confirm that retention is very low and approaching zero after about 8 days of drift for most conditions. The analyses also reinforce the importance of dispersion as a critical unknown; under conditions of extreme low flows and low pool levels, a small but non-zero retention rate was obtained after 12 days of drift.

The water in Fort Peck thermally stratifies resulting in a colder and denser water layer at depth. When this cold water is released, it substantially cools the riverine environments downstream. Average and maximum water temperatures immediately downstream of Fort Peck Dam can be reduced by as much as 10.8°F (6°C) and 18°F (10.4°C), respectively (Fuller and Braaten 2012). These effects decrease with distance from the dam, but are still measurable over 180 miles (290 km) downstream where average and maximum temperatures are still 1.8°F (1°C) cooler than Missouri River reaches above Fort Peck Reservoir (Fuller and Braaten 2012).

The water intakes for Fort Peck Dam are on the bottom of the reservoir making it challenging to develop and implement design options to discharge warm surface waters downstream. In 2009, USACE completed the Fort Peck Dam Temperature Control Device Reconnaissance Study. Ten alternatives to increase downstream water temperatures were evaluated for further consideration (USACE 2009b). The use of a flexible curtain to act as a submerged weir became the focus through subsequent investigations (USACE 2012b). This option employs a flexible curtain suspended a set distance below the water surface using a float system; the curtain extends to the lake bed and is held in place with ballast and anchors. The intake draws warmer water from the upper portion of the water column over the current crest, rather than drawing cold water from the bottom of the reservoir (USACE 2012b). USACE does not consider this option feasible due to an estimated short life cycle (i.e., 10–20 years), uncertainties with meeting downstream temperature targets, high construction and operation and maintenance costs, and significant dam operation safety concerns.

Effects analysis modeling suggests that few combinations of aforementioned management actions on the Missouri River (alteration of Fort Peck flows, temperature modifications at Fort Peck, and drawdown of Lake Sakakawea) are likely to avoid recruitment failure (Fischenich et al. 2014). As stated previously, a reconnaissance study conducted in 2009 cited the challenges presented by management options at Fort Peck Dam (USACE 2009b), and adjustments to promote retention and recruitment (e.g. extreme low flows and low pool levels) involve substantial trade-offs. Prohibitively high costs and/or risk and uncertainty related to dam operations and dam safety were associated with each option. Actively managing the hydrology below Fort Peck Dam to provide the appropriate volume and temperature at the correct time would be a significant challenge containing hydrological, physical, and biological uncertainty with a small probability for success (USFWS 2015b). Approximately 90 percent of the tagged adult pallid sturgeon in the upper Missouri River population use the Yellowstone River during the spawning period (May – July) (Braaten et al 2015), however, a few pallid sturgeon have migrated into the Missouri River during the spawning period on several occasions, including 2018. The only documented spawning was during a historic flood when spawning was suspected on the Missouri River near Ft. Peck, although most still chose the Yellowstone River. In 2018, a year when spillway releases occurred during spawning migrations, several pallid sturgeon migrated up the Missouri River and stayed in or near the spillway channel but apparently left the area prior to spawning. Therefore, although there is limited evidence that some fish may be attracted up the Missouri River in some conditions, spawning has only been observed in one year with extreme flow conditions. Therefore, implementation of Fort Peck management actions or a drawdown of Lake Sakakawea were not retained for alternative development due to the high level of uncertainty regarding their feasibility to achieve desired biological results and documented issues regarding their technical feasibility. In recognition of the scientific uncertainty surrounding Fort Peck flow adjustments, USACE agreed to formulate test flows from Fort Peck and an AM framework for their implementation during formal ESA Section 7 consultation on this plan. Studies under the framework may include additional drift studies, tracking of fish and documentation of spawning locations, telemetry evaluations and methodology improvements, risk analysis, and engineering studies. Implementation of an identified hydrograph to test hypotheses would be considered; however, depending on the specifics of the test hydrograph, may be outside the scope of this EIS.

Meaningful levels of recruitment in this reach are improbable given the current constraints. However, uncertainties regarding both physical and biological conditions and responses to management action are sufficient to warrant continued study under an adaptive management framework. Advancements in the state of the science with regard to these uncertainties could open the door to some management actions.

2.5.2.2 Evaluate Fish Passage at Intake on Yellowstone River

The Yellowstone River is the largest tributary to the Missouri River. While the Yellowstone River contains several low head diversion weirs that individually and cumulatively affect some fish migrations (Helfrich et al. 1999), these low weirs have insignificant effect on temperature and discharge when compared to the Mainstem Missouri River dams and reservoirs. As a result, the Yellowstone River retains a more natural hydrograph and temperature profile as well as less altered habitat-forming processes than the Missouri River.

Of the six diversion weirs on the river, the lowermost, Intake Diversion Dam, is approximately 71 miles (115 km) from the confluence with the Missouri River and limits most upstream movements of pallid sturgeon (Bramblett and White 2001; DeLonay et al. 2016). Although Intake Diversion Dam negatively affects upstream migrations of pallid sturgeon, passage over or around this structure has been occasionally documented (DeLonay et al. 2016). The U.S. Bureau of Reclamation operates Intake Diversion Dam on the Yellowstone River. This structure was built in 1905 as a 12-foot high wood and stone dam to divert water from the Mainstem into an irrigation canal that runs parallel to the river and provides a dependable water supply for adjacent lands. Studies suggest that the Intake Diversion Dam impedes upstream migration of pallid sturgeon and their access to spawning and larval drift habitats (Bramblett 1996; Bramblett and White 2001; Fuller et al. 2008; Backes et al. 1994).

The total available drift distance from Intake Diversion Dam on the Yellowstone River to the headwaters of Lake Sakakawea is approximately 90 miles (144 km). The next diversion dam upstream from Intake Diversion Dam is Cartersville Dam which is located about 168 miles (270 km) upstream from Intake Diversion Dam or 258 miles (415 km) from the headwaters of Lake Sakakawea (Figure 2-4).

Improvements to fish passage are expected to be a substantial step forward in assisting the long-term survival and recovery of the pallid sturgeon in the upper basin by providing access to up to 165 miles in upstream reaches of the Yellowstone River. The hydrology, thermal conditions, and sediment regime are relatively undisturbed in the Yellowstone River, thereby potentially providing supporting habitat conditions for pallid sturgeon. Also, the additional drift distance is expected to better allow for adequacy of larval drift, which is currently hypothesized to be a requirement to support natural recruitment in the upper basin. According to the effects analysis, available drift/dispersal distance emerged as a fundamental limitation on pallid sturgeon recruitment in the upper river (Jacobson et al. 2016b).

Since 2010, the Bureau of Reclamation and USACE have collaborated on several studies that evaluated proposed alternatives for modification to Intake Diversion Dam that would reduce entrainment and improve fish passage. In October 2016, the Bureau of Reclamation and USACE released a final EIS that evaluated five action alternatives. The alternatives evaluated include a rock ramp, bypass channel, modified side channel, multiple pumps, and multiple pumps with conservation measures. The final EIS identified the bypass channel as the preferred alternative. The Record of Decision was signed in December 2016.

Impacts associated with the construction and operation of the Intake Diversion Dam Modification project are evaluated as part of the EIS the Bureau of Reclamation and USACE have jointly prepared for the Intake Diversion Dam Modification project. In light of the independent evaluation and implementation of this project, the MRRMP-EIS primarily focuses on developing and analyzing management actions that may reduce the effects to the pallid sturgeon in the upper Missouri River between Fort Peck and Lake Sakakawea. Additionally, expanded monitoring and assessment of migration, spawning, hatch, drift, and recruitment at Intake Diversion Dam is incorporated to all plan alternatives in this EIS and the proposed AM framework accounts for the use of this information in assessing future management needs of pallid sturgeon in the upper basin.

2.5.2.3 Propagation and Augmentation

The 2003 Amended BiOp (USFWS 2003) calls for USACE to assist in pallid sturgeon propagation and augmentation efforts. The Pallid Sturgeon Conservation Augmentation Program (PSCAP) uses stocking to supplement year class structure to the pallid sturgeon population due to the lack of natural recruitment in the Missouri River. The PSCAP also preserves the remaining population genetics and structure. Surplus individuals are also used for scientific studies to better understand uncertainties in the upper Missouri River.

Wild pallid sturgeon are collected each spring and brought into hatcheries for spawning and the eventual stocking of their progeny in cooperation with USFWS and state agencies and in accordance with USFWS guidance. Three federal hatcheries (Gavins Point National Fish Hatchery in Yankton, South Dakota, Garrison Dam National Fish Hatchery in Riverdale, North Dakota, and Neosho National Fish Hatchery in Neosho, Missouri) and two state hatcheries (Blind Pony State Fish Hatchery in Sweet Springs, Missouri and Miles City State Fish Hatchery in Miles City, Montana) are involved with propagation of Missouri River pallid sturgeon. Pallid sturgeon are stocked into four Resource Priority Management Areas. In 2014, the hatcheries stocked a combined 24,309 fingerling and yearling-sized pallid sturgeon from the 2013 and 2014 year classes into the Resource Priority Management Areas (USACE 2015b). USACE supports pallid sturgeon propagation and augmentation efforts through the provision of annual funding. This management action was retained for alternatives development.

2.5.3 Lower River Pallid Sturgeon

The following management actions were considered in developing alternatives to avoid a finding of jeopardy to the pallid sturgeon in the lower Missouri River from USACE actions on the Missouri River.

2.5.3.1 Channel Reconfiguration

Channel reconfiguration consists of the physical manipulation of the river bed or bank to create or improve areas for provision of specific pallid sturgeon habitats thought to be limiting. Examples include adjustments to navigation training or bank stabilization structures, channel widening (i.e., top-width widening), floodplain modifications or other adjustments to channel geometry, placement of structures to encourage development of needed habitat or habitat complexity, chute development, or adjustments to existing chutes.

The intent of channel reconfigurations is to provide more or better functioning habitats that may be presently limiting to pallid sturgeon recruitment. The effects analysis identified four functional habitats that may be limiting (Jacobson et al. 2016b):

- Spawning habitat: Areas of coarse substrate, convergent flow with high turbulence and velocities; conducive to attraction of reproductive adults, spawning, fertilization, incubation and hatch of free embryos.
- Food-producing habitats: Stable, fine substrate conducive to hosting chironomid larvae populations for age-0 pallid sturgeon food. These are deposition areas with current velocities 0–0.08 m/s.
- Foraging habitats: Combinations of depth and velocity to provide for energy-efficient access to drifting food. Present data indicate age-0 catch per unit effort peaks at 1–3 m depth and 0.5–0.9 m/s current velocity (Ridenour et al. 2011).
- Free embryo interception, retention: Hydraulics that promote free-embryo transport from thalweg and retention in channel-marginal areas. Interception, food-producing habitats, and foraging habitats can be considered as interception rearing complexes (IRCs), discussed further in Section 2.6.3. A more-detailed description of locating IRC reconfiguration projects in relation to geomorphology is located in Appendix E.1 of the SAMP.

USACE has implemented channel reconfiguration projects in compliance with the BiOp for approximately the last 13 years. Projects would continue to be designed in a manner that would not adversely affect the current authorized purposes of the Missouri River, including flood control and navigation. Designs for early life stage pallid sturgeon habitat under each alternative will be developed to maintain sufficient flow in the navigation channel, and not result in deposition that would cause shoaling within the navigation channel or create other hazards to navigation. USACE routinely monitors the Missouri River navigation channel and coordinates these efforts with the U.S. Coast Guard and commercial navigators on the river. In areas where navigation impediments are identified, USACE works with the U.S. Coast Guard and commercial navigators to develop and implement corrective action that will restore and maintain the authorized 9-feet deep by 300-feet wide navigation channel.

Designs for pallid sturgeon early life stage habitat will be developed to ensure that the projects do not adversely affect existing flood risk management systems. As with the BSNP, USACE routinely monitors the performance of shallow water habitat (SWH) projects to determine if these projects are contributing to adverse impacts on adjacent flood risk management systems. If issues are identified, USACE works with the affected levee district to develop and implement a corrective plan. Projects will be designed in a manner that does not increase erosion on adjacent private lands or adversely impact public roads, bridges, levee and drainage systems, sewer lines, drinking water intakes, etc. Sampling of material for contaminants would continue to take place for each project along with site-specific NEPA analysis. Each site-specific analysis seeks to identify and avoid impacts to sensitive resources that may be present including biological, Tribal, cultural, and socioeconomic resources. For each site-specific project, USACE coordinates with the Tribes, the public, stakeholders, and resource agencies. These projects would continue to be implemented on existing public lands, to the extent possible, or on lands that are acquired from willing sellers.

Channel reconfiguration to create functional habitats using various potential measures was retained for alternatives development. The suite of actions to create functional habitats that could be implemented under this management action include:

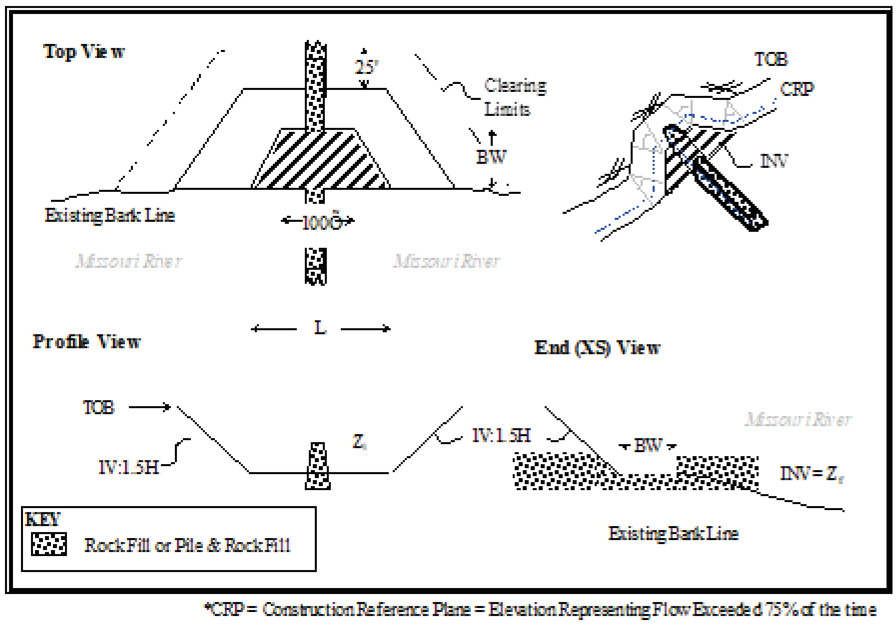

Figure 2-5. Top View of a Typical Bank Notch

- Structure modifications: These actions modify existing Missouri River control structures to restore processes that may create habitat.
  - Bank notches: A bank notch typically consists of excavating a 100- to 150-foot long, 75-foot-wide section of the high bank along with the underlying 75-foot-wide section of buried L-Head or straight out dike (Figure 2-5). The invert of a bank notch is excavated to 5 feet below the Construction Reference Plane using land-based equipment. Construction Reference Plane is defined as a sloping datum representing the water surface elevation met or exceeded 75 percent of the time during the April to November navigation season. Bank notches may be implemented in areas where USACE has a property interest. Long-term effects of a bank notch are erosion of the high bank and widening of the top-width of the river.

Figure 2-6. Dike Notches

- 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 (Figure 2-6). 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 a localized increase in flow velocity in areas in and immediately surrounding the notch. A deepening of the local scour hole downstream of the notch and adjacent deposition forming at an elevation at or below the top of the dike can also occur. Flows conveyed by a dike notch typically represent 1-3% of the total river flow for river levels between the notch invert and crown of the dike, and reduce at higher flows above the top of the dike. Notches placed immediately adjacent to the bank may be implemented in areas where USACE has a property interest as slight bank erosion immediately downstream of the dike would be expected.
- Revetment notches and lowering: A revetment notch consists of excavating a 50- to 100-foot-wide section of a stone-fill revetment to an elevation 5 feet below the Construction Reference Plane using water- or land-based equipment (Figure 2-7). Physical changes expected from a revetment notch may include a scour hole on the land side or increased connectivity to areas disconnected from the main river channel during flows lower than the top of the river structures but above the elevation of the notch (e.g., a revetment notch at the downstream end of an open area would not necessarily develop a scour hole on the land side of the notch). 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. Revetment notches may be implemented in areas where USACE has a property interest or where impacts to private property and other authorized purposes would not occur.

Figure 2-7. Aerial View of a Revetment Lowering

- Placement of new structures: New structures may be placed in the river to encourage formation of habitat. Examples of potential new structures include chevrons (Figure 2-8), rootless dikes, and reverse sills. USACE would only place new structures in areas where there would not be an impact to other authorized purposes.

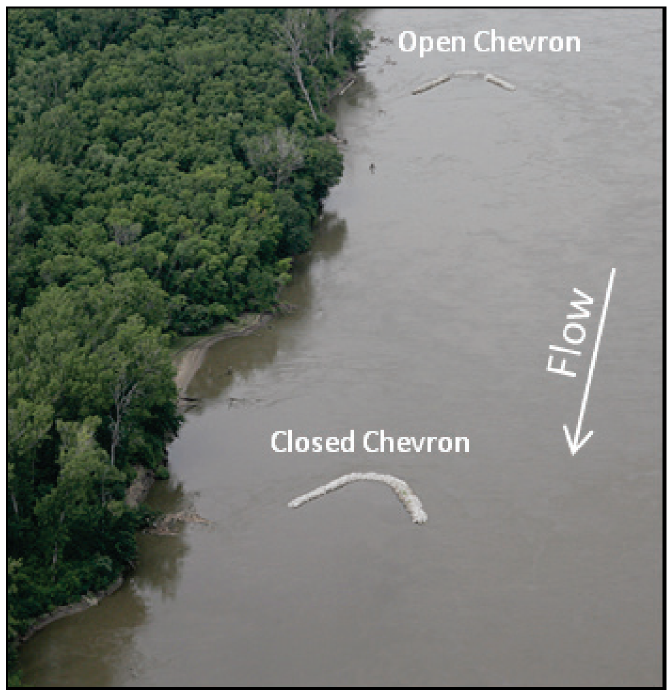

Figure 2-8. Aerial View of Chevron Structures

- Off-channel habitat: Restoration of off-channel habitat includes the creation of chutes and backwaters.
  - Flow-through chute construction: A chute is a side-channel of a river (Figure 2-9), which diverts flow from the main channel through the chute, and back into the main channel, thus creating an island. Construction involves excavation of side channels with possible multiple connections to the Missouri River in addition to the entrance and exit. The multiple connections are referred to as secondary connections or tie channels. Construction can be accomplished through the use of hydraulic dredges or use of excavators to remove materials. Chutes provide a dynamic environment with active bank and bar building processes. A properly formulated chute will function in both normal and high flow events. Chutes typically include one or more grade control structures to limit degradation within the chute and maintain the proper flow split between the chute

(typically less than 10 percent of total river volume flows in the chute) and the main channel.

Figure 2-9. Side-Channel Chute Example

- 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. Backwaters are constructed in a similar manner to chutes, but provide relatively still water. Excavation is typically performed by hydraulic dredge. Some of the excavated material would be distributed in the main channel adjacent to the excavation zone. The remaining material would be discharged into the thalweg of the Missouri River where it would become entrained into the bedload of the river.

- Channel widening or top-width widening (Figure 2-10): Channel widening projects involve the use of mechanical equipment to lower the adjacent floodplain and bank of the Missouri River to create habitat and widen the top-width of the river channel. Excavation is typically performed by hydraulic dredge. Some of the excavated material would be distributed in the main channel adjacent to the excavation zone. The remaining material would be discharged into the thalweg of the Missouri River where it would become entrained into the bedload of the river.

Figure 2-10. Top-Width Widening Example

2.5.3.2 Propagation and Augmentation

The propagation and augmentation management action for lower river pallid sturgeon is the same as that described for upper river pallid sturgeon and was retained for alternatives development.

2.5.3.3 Alter Flow Regime at Gavins Point

Several management hypotheses are linked to alteration of the flow regime at Gavins Point as a management action. The nature of the flow alteration varies by hypothesis; however, all relate to System adjustments to achieve a more “naturalized” hydrograph downstream of Gavins Point Dam. Naturalization of the flow regime is considered incremental changes that move the flow regime towards the hydrological attributes (magnitude, duration, timing, or frequency) that would exist in the absence of dams and reservoirs, while recognizing social and economic constraints. More generally, naturalization refers to the process of using characteristics of the natural ecosystem to guide elements of river restoration, but constrained by social and economic values (Rhoads et al. 1999; Jacobson and Galat 2008).

Alteration of the flow regime for a pallid sturgeon spawning cue in the lower river would necessitate increased Gavins Point Dam releases during the spring relative to current operations. The exact characteristics of a spawning cue pulse that would elicit a spawning response are not known. ISAP found no evidence that managed spring pulses are necessary to provide cues for pallid sturgeon spawning (Doyle et al. 2011). Increases in magnitude and duration of pulsed releases beyond those implemented in the spring rise technical criteria (USACE 2006a) would therefore be necessary under the hypothesis that pulses are necessary to cue successful spawning. It is also hypothesized that alteration of the flow regime for enhanced primary and secondary production could be achieved through flow pulses that connect with low-lying lands and floodplains in the spring or by low flows that create shallow, warm water in the summer and fall. However, there is no evidence that nutrients, invertebrates, or forage fish in the lower Missouri River will increase in response to a managed spring pulse and shallow water (Doyle et al. 2011). Summer and fall low flows would result in decreased velocities and energetic demands, and decreased effective drift distances. These low flows would necessitate decreased Gavins Point Dam releases during the summer and fall seasons relative to current operations. Implementation of any of these Gavins Point Dam releases would require adjustments to System-wide reservoir operations. This management action was retained for alternatives development.

2.5.3.4 Temperature Management at Gavins Point Dam

This management action includes the operation of a temperature management system at Gavins Point Dam and/or Fort Randall Dam to increase the temperature of water released from Gavins Point Dam in May to serve as an aggregation and spawning cue for reproductive pallid sturgeon in the lower river. Current Fort Randall dam operations and configurations result in the release of colder water than would naturally occur; however, there is no clear evidence that this is also the case at Gavins Point Dam (Jacobson et al. 2016b). Quantitative data and models to support the hypothesis underlying this management action are lacking (Jacobson et al. 2016b). The effects analysis associated a high degree of uncertainty with this management action and stated that it had a considerable risk of failure if implemented with currently existing information (Jacobson et al. 2016b). As with temperature control options evaluated for Fort Peck Dam (USACE 2009b), options to implement this action would also have high life cycle costs. This management action was eliminated from further consideration because evidence is lacking to demonstrate it could be effective at contributing to the species objectives. It is also considered inefficient due to anticipated high costs associated with implementation.

2.5.4 Habitat Development and Land Management on MRRP Lands

The land requirements for implementation of habitat creation can occur (1) on existing public lands if the state or federal agency owning the property is willing to cooperate with USACE on the project; or (2) on land acquired in fee title. Based on consideration of cost and implementation risks, it is anticipated that most or all land acquisition will continue to be from willing sellers. USACE must typically purchase enough land to accommodate the habitat project and provide a buffer between the project and adjacent lands. Based on an assessment of past pallid sturgeon SWH projects implemented by USACE, it was determined that an average of 7.7 acres of land are acquired for every 1 acre of pallid sturgeon habitat needed. USACE would develop habitat on lands consistent with its authorizations under the WRDA 1986, 1999, and 2007. Habitat development has included chutes and side channels, shallow water habitat, backwater areas, slack water habitats, wetlands, bottomland forest, and native prairie. The WRDA land acquisition authority is a result of USACE mitigation recommendations under the Fish and Wildlife Coordination Act and therefore cannot be separated from the requirement that lands acquired for pallid sturgeon habitat construction also serve to mitigate for the BSNP impacts. The land acquisition authority for mitigation of the construction of the BSNP is not being reassessed through this Management Plan, and the total mitigation authority acres remain at 166,750 acres. USACE has acquired approximately 66,616 acres of the authorized 166,750 acres, nearly 40 percent. Land acquisition and habitat development under the BSNP mitigation authority is not limited to pallid sturgeon habitat and can include restoration of native vegetation, wetlands, bottomland forest, backwaters and other Missouri River habitats lost due to the BSNP. It is assumed real-estate purchases for the 15-year implementation timeframe would continue to prioritize land that contributes to jeopardy avoidance, while still constituting appropriate acquisition and development under the aforementioned WRDA authorities. Land acquisition itself does not necessarily equate to Fish and Wildlife Coordination Act mitigation, rather, the determination of the appropriate land cover and habitat types for a parcel of land requires a site-specific analysis, which would be conducted in tandem with planning for site-specific aquatic habitat related specifically to jeopardy avoidance.

USACE has worked with USFWS and the natural resource or conservation agencies of the four lower basin states (Iowa, Kansas, Missouri, and Nebraska) to develop and implement fish and wildlife habitat restoration plans for MRRP lands acquired under WRDA authorities. Historically, USACE has established native vegetation, created wetlands, restored riparian buffers, and performed other restoration activities. Acquired lands are managed by USACE, state fish and wildlife agencies, or USFWS. USACE performs operation and maintenance activities, maintains public access, and conducts best management practices on the lands in accordance with MRRIC's recommendation of a “Good Neighbor Policy.” These activities generally include noxious weed control, controlled burns, maintenance of roads and signage, and temporary agricultural leasing for those areas, which have not yet been restored.

Table 2-4. Summary and Status of Management Actions

Management Actions Considered	Retained for Further Consideration in Alternatives Development?
Least Tern and Piping Plover Actions	
ESH Flow Releases	Yes
Mechanical ESH Construction on River	Yes
Mechanical ESH Construction on Reservoir Shorelines or Islands	No
"Off-Channel" Habitat Creation/Mechanical Creation of Hydrologically Connected non-ESH Habitat on River segments	No
Modification or Augmentation of Existing Sandbars	Yes
Vegetation Management	Yes
Habitat Conditioning Flows	No
Reservoir Water Level Management	Yes
Lowered Nesting Season Flows	Yes
Flow Management to Reduce Take	Yes
Predator Management (Predator Removal and Nest Caging)	Yes
Human Restriction Measures	Yes
Channel Modification to Increase Width	No
Sediment Redistribution	No
Pallid Sturgeon Actions	
Fort Peck Actions/Lake Sakakawea Drawdown	No
Evaluate Fish Passage at Intake on Yellowstone River	Yes
Propagation and Augmentation	Yes
Channel Reconfiguration	Yes
Alter Flow Regime at Gavins Point Dam	Yes
Temperature Management at Gavins Point Dam	No
Habitat Development and Land Management on MRRP Lands	Yes

2.6 Pallid Sturgeon Alternatives Development

Despite considerable effort during the effects analysis process, the identification of the specific factors causing recruitment failure for pallid sturgeon and a clear nexus between management actions and population response was not identified for the lower river (downstream of Gavins Point Dam) (Jacobson et al. 2016b). As a result, development of alternatives for pallid sturgeon was a collaborative process between USACE, USFWS, and the effects analysis team relying on the best available science. There were several key milestones during this process that shaped the concepts of the actions and alternatives formulated for the lower river pallid sturgeon. These milestone events are summarized here.

2.6.1 Identification of Lower Pallid Sturgeon Limiting Factors

In September 2014, USACE convened a group of pallid sturgeon experts to elicit their expertise in the alternatives development process. This workshop was not part of the effects analysis; however, it attempted to build on the results of the effects analysis in developing alternatives for the Management Plan. As part of preparation for this workshop and during the course of the workshop, a set of "limiting factors" that tied to the management hypotheses were identified and defined (Table 2-5). During the workshop, the experts were facilitated through an iterative process of ranking the "most likely" factor perceived to be limiting the lower river pallid sturgeon population (Long 2014). An outcome of this process was the transition to structuring plan development around the limiting factors that were identified and defined (Table 2-6). The presentation of limiting factors in Table 2-5 and Table 2-6 does not reflect any order or importance or prioritization.

Table 2-5. Lower River Pallid Sturgeon Limiting Factors Associated with the Management Hypotheses

Management Hypothesis	General Management Action	Limiting Factor
Naturalization of the flow regime at Gavins Point will improve flow cues in spring for aggregation and spawning of reproductive adults, increasing reproductive success.	Alter flow regime at Gavins Point	Insufficient spawning cue signals
Naturalization of the flow regime at Gavins Point will improve connectivity with channel-margin habitats and low-lying floodplain lands, increase primary and secondary production, and increase growth, condition, and survival of exogenously feeding larvae and juveniles.		Insufficient food-producing habitat for age-0 pallid sturgeon
Naturalization of the flow regime at Gavins Point will decrease velocities and bioenergetic demands, resulting in increased growth, condition, and survival for exogenously feeding larvae and juveniles.		Insufficient foraging habitat for age-0 pallid sturgeon
Alteration of the flow regime at Gavins Point can be optimized to decrease Mainstem velocities, decrease effective drift distance, and minimize mortality.		Inappropriate drift dynamics
Operation of a temperature management system at Fort Randall and/or Gavins Point will increase water temperature downstream of Gavins Point, providing improved spawning cues for reproductive adults.	Temperature management at Fort Randall and Gavins Point	Insufficient spawning cue signals
Re-engineering of channel morphology in selected reaches will create optimal spawning conditions—substrate, hydraulics, and geometry—to increase probability of successful spawning, fertilization, embryo incubation, and free-embryo retention.	Channel reconfiguration	Insufficient spawning habitat
Re-engineering of channel morphology in selected reaches will increase channel complexity and bioenergetic conditions to increase prey density (invertebrates and native prey fish) for exogenously feeding larvae and juveniles.		Insufficient food-producing habitat for age-0 pallid sturgeon
Re-engineering of channel morphology will increase channel complexity and minimize bioenergetics requirements for resting and foraging of exogenously feeding larvae and juveniles.		Insufficient foraging habitat for age-0 pallid sturgeon

Management Hypothesis	General Management Action	Limiting Factor
Re-engineering of channel morphology in selected reaches will increase channel complexity and serve specifically to intercept and retain drifting free embryos in areas with sufficient prey for first feeding and for growth through juvenile stages.	Channel reconfiguration (continued)	Insufficient interception habitat
Stocking at optimal size classes and in optimal numbers will increase growth rates and survival of exogenously feeding larvae and juveniles.	Lower basin propagation	Insufficient number/fitness of adults
Stocking with appropriate parentage and genetic diversity will result in increased survival of embryos, free embryos, exogenously feeding larvae, and juveniles.		Insufficient number/fitness of adults

Table 2-6. Lower River Pallid Sturgeon Limiting Factors

Limiting Factor	Definition of Limiting Factor
Insufficient number / fitness of adults	Insufficient numbers and/or fitness of reproductively mature adults in the lower Missouri River to allow for successful aggregation prior to spawning and to allow for successful spawning.
Insufficient spawning cue signals	The combination of peak flow intensity, timing, duration, shape, temperature and possibly other issues is not sending sufficient spawning cues.
Inappropriate drift dynamics	An inappropriate Mainstem flow regime is resulting in problematic velocities, drift time, and geographic dispersal.
Insufficient spawning habitat	Insufficient spawning habitat (defined here as high quality, functioning spawning habitat, in contrast to the ubiquitous but (arguably) ineffective low-quality habitat – outside, revetted bends).
Insufficient interception habitat	Insufficient habitat conditions to move free embryos from the thalweg into supportive channel-margin habitats.
Insufficient food producing habitat for age-0 pallid sturgeon	Insufficient habitat that supports populations of chironomids and other small invertebrate food items for first feeding.
Insufficient foraging habitat for age-0 pallid sturgeon	Insufficient habitat where hydraulic conditions and availability of food items combine to produce energetically favorable conditions for growth.

2.6.2 Drift Dynamics Limiting Factor

The concept of inappropriate drift dynamics is multi-faceted and includes three related hypotheses: (1) there is inadequate drift distance between spawning sites and lethal conditions for free embryos downstream; (2) free embryos are unable to exit the main channel before starving; and (3) free embryos die from direct damaging effects of flow turbulence. The first two of these were generated by the effects analysis process whereas the third arose during the workshop described in Section 2.6.1.

The first hypothesis regarding inadequate drift distance has strong support in the upper Missouri River, but evidence for lethal effects at long drift distances in the lower Missouri River or Middle Mississippi River is lacking. The SAMP includes studies on drift modeling, genetics, and microchemistry of pallid sturgeon fin rays to determine the origins and dispersal of pallid sturgeon. These studies are designed to determine where pallid sturgeon larvae complete their dispersal process and whether they survive.

The second hypothesis relates to the interception function of interception rearing complexes. Management actions related to interception of free embryos into appropriate foraging habitats so they do not starve in the main channel flow are addressed in Section 2.6.3.

The third hypothesis is speculative and based on the fragile nature of pallid sturgeon free embryos 0 to 5 days old. Presently there is no laboratory or field-based evidence to support the conjecture. Management actions to make measurable changes to decrease turbulent intensity over the entire lower river would require a considerable cost investment or perhaps very low flow releases from Gavins Point. Laboratory studies are currently planned under the SAMP to quantify turbulent intensities needed to physically damage or kill free embryos.

2.6.3 Concept of the "Interception and Rearing Complex"

During the course of the effects analysis, a leading concept emerged regarding the formulation of management actions for three of the functional habitat types identified by the effects analysis team for lower river pallid sturgeon: interception, food-producing, and foraging habitat. This concept was termed interception and rearing complexes (IRCs) (Jacobson et al. 2016b). Interception, food-producing, and foraging habitats for age-0 pallid sturgeon are inter-related, as it is the combination of habitats that would result in retention and survival of young fish in supportive habitats. To represent this combination, the effects analysis team (Jacobson et al. 2016b) defined IRCs that are complex areas that include hydraulics to intercept drifting free embryos combined with food-producing habitats and foraging habitats. Any of these three habitat types could be limiting to growth and survival, and a limiting role could shift over time as proportions of the habitats shift or as a population grows.

IRCs are areas that meet the functional definitions laid out in Jacobson et al (2016b). For the purpose of establishing targets and measuring progress, the physical definitions of IRCs are currently identified as follows: (1) food-producing habitat occurs where velocity is less than 0.08 meters per second (m/s) (0.3 feet per second [fps]); (2) foraging habitat is defined as areas with 0.5–0.7 m/s (1.6 to 2.3 fps) velocity and 1–3 m (3.3 to 9.8 ft) depth; and (3) interception habitat has been qualitatively described as zones of the river where hydraulic conditions allow free embryos to exit the channel thalweg. A functional IRC exists where the juxtaposition of the described habitats is such that all three functions are performed and collectively contribute to survival to age-1 (Figure 2-11). A more detailed discussion of the quantitative representation of IRCs can be found in the SAMP. Habitat definitions could be adjusted as warranted based on monitoring and evaluation, or new information regarding observed use of different habitats by age-0 pallid sturgeon. Research is continuing on conditions that create interception hydraulics. The EA hypothesized that effective interception hydraulics occur where flow expands downstream from a wing dike followed by a relatively long section of river without wing dikes (Figure 2-11). Depending on the particular river bend, creating effective interception hydraulics on the lower Missouri River may require only modest changes to wing-dike geometries or more extensive modifications.

The availability of food-producing and foraging habitats varies with flow, as does the local hydraulic field at any location (and hence the potential for interception and retention). Consequently, IRC habitat is flow-dependent and time-variant and can be affected by both mechanical manipulations of river geometry and flow management actions. IRC habitat would likely be constructed to maximize habitat availability over the range of flows when age-0 pallid sturgeon transition from the drifting stage to benthic oriented, exogenous feeding individuals (USACE 2017, Appendix G). The metric used to calculate the amount of IRC habitat created, acre-days per year are calculated based on how the flow regime and channel configuration result in cumulative days of availability of suitable habitat during the growing season (for more details see USACE 2017, Appendix H).

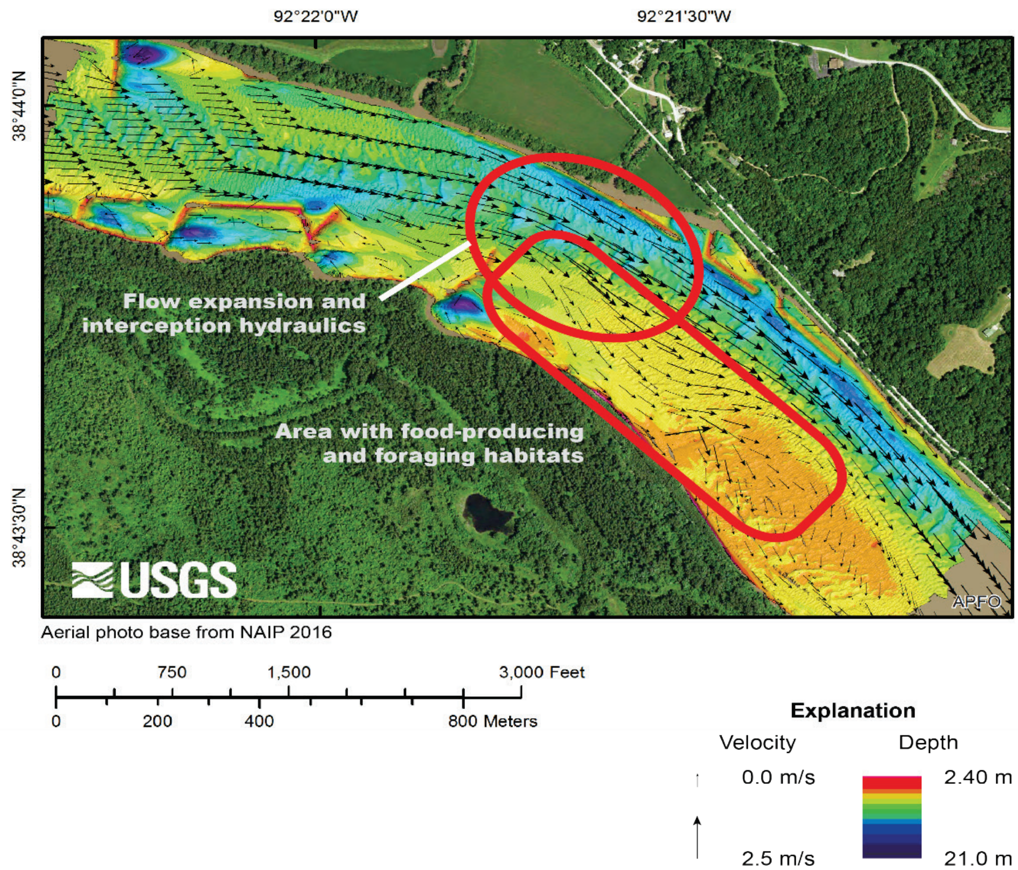

Figure 2-11. Interception and Rearing Complex Visualization

IRCs and the optimum parameters for flow depth and velocity are still in an experimental phase that will be further refined through the adaptive management process for IRC habitat. Adaptive management would allow for inclusion of monitoring data results in future IRC design. Since the mid-1990s, USACE has constructed numerous habitat projects that have experienced a broad range of flow events including drought and flood. Construction of top width widening projects, that are thought to provide for IRC habitat, is a more recent development that has occurred at four separate sites since 2012. Although each site has project-specific issues and broad generalizations should be restricted (due to the limited time period of actual project experience), it does appear that top width widening project construction is feasible without incurring large scale maintenance requirements. Past experience with extreme flows such as those that occurred in 2011, which corresponded to roughly a 0.02 percent annual chance exceedance event (e.g., 500-year return interval), demonstrate that habitat projects should be expected to experience a degree of change along with the entire floodplain. Climate change and other factors could affect future river flows. There are several factors that would mitigate the potential for minor flow changes to substantially affect pallid sturgeon habitat performance, such as the reservoir system partially mitigating flow change magnitude. IRCs would adjust through geomorphic processes, and constructed habitat levels could be altered to reflect the prevailing flow regime and optimum habitat performance levels that would be identified following the adaptive management process.

Previous channel restoration efforts on the lower Missouri River focused on adding shallow-water habitat (SWH, 0–5 feet deep, 0–2 feet per second current velocity). Although the historical river channel had more SWH compared to the engineered channel, the role of SWH in growth and survival was not characterized in terms of the three specific IRC attributes. IRCs, by comparison, are designed specifically to provide three ecological attributes (or habitats) to support sturgeon growth and survival. These three attributes can be individually designed to provide optimal habitat and survival benefits tailored to particular river reaches.

IRCs occupy locations similar to SWH projects, but they are designed specifically to provide the three needed attributes. Under an adaptive management approach, the criteria for design and evaluation will be continuously updated as new information becomes available. The present definitions of food-producing and foraging habitats overlap in part with SWH; however, food-producing habitat can be substantially deeper, and foraging habitat is both deeper and faster. In addition, the IRC concept acknowledges that habitat areas and conditions change substantially with the amount of flow in the river and therefore change over time. To account for changing area with flow, we inventory IRC habitat area as acres that exist during the sturgeon's growing season, which is expressed as acre-days per year. One acre of IRC habitat, with the appropriate depths and velocities, available for one day, is equal to one acre-day. This calculation is accomplished by using computer models of river flow. The calculation of acre-days per year allows for evaluation of how changes in hydrologic conditions would affect IRC availability and functions.

2.6.4 Lower Pallid Sturgeon Framework and U.S. Fish and Wildlife Service Jeopardy Avoidance Criteria

On November 2, 2015, USFWS provided USACE with a Planning Aid Letter (USFWS 2015c) confirming support for the "Lower Missouri River Pallid Sturgeon Framework, Targets and Decision Criteria" (USFWS and USACE 2015) (refer to Appendix B: Fish and Wildlife Coordination Act Correspondence). This document provided guidance for actions to be included in this MRRMP-EIS, and its structure has been used to guide the formulation of Alternatives 3–6. Key principles underpinning the framework are as follows (extracted from USFWS and USACE 2015):

- Given the lingering uncertainties regarding the scope and scale of the management actions necessary for USACE to avoid a finding of jeopardy to pallid sturgeon, a strategy reliant upon a progressive AM program is the most effective way to manage risks to the pallid sturgeon.
- The framework is expected to accelerate the identification of recruitment bottlenecks, resulting in a more strategic and focused implementation of appropriate management actions. This approach has the added benefit of minimizing impacts to stakeholders and Tribes and avoiding unnecessary implementation costs.
- The artificial propagation program would be continued throughout the framework's implementation, and improvements to that program related to genetic concerns, disease, stocking size, etc., would be pursued consistent with USFWS propagation plan under development.

- Implementation of management actions at Level 3 (Table 2-7) for each hypothesis would be required within a specified timeframe, provided the hypotheses associated with the action are not rejected by that time.
- At any time during the framework's implementation, it may become apparent that: (1) a particular action is not needed; (2) a proposed action requires modification to be effective; or (3) that some new action not previously evaluated is required.

The framework for the lower river consists of four levels of activity as described in Table 2-7. As information is developed from Level 1 and 2 studies or through monitoring of effectiveness of management actions, the framework's decision criteria would be used to determine when and what action should follow. The framework includes the possibility that Level 1 and 2 science proceeds concurrently with Level 3 or 4 implementation to address continuing information needs. Chapter 4 describes implementation of actions within this framework in more detail for the preferred alternative.

Table 2-7. Pallid Sturgeon Framework for Lower River

Level 1: Research	Population-level biological response IS NOT expected	Studies without changes to the System (laboratory studies or field studies under ambient conditions).
Level 2: In-river testing		Implementation of actions at a level sufficient to expect a measurable biological, behavioral, or physiological response in pallid sturgeon, surrogate species, or related habitat response.
Level 3: Scaled implementation	Population-level biological response IS expected	In terms of reproduction, numbers, or distribution, initial implementation should occur at a level sufficient to expect a meaningful population response progressing to implementation at levels, which result in improvements in the population. The range of actions within this level is not expected to achieve full success (i.e., Level 4).
Level 4: Ultimate required scale of implementation		Implementation to the ultimate level required to remove as a limiting factor.

2.7 Bird Alternatives Development

The MRRMP-EIS PDT worked with the effects analysis team to formulate alternatives for the least tern and piping plover. This process focused on the formulation and modeling of alternatives that use Missouri River reservoir release changes to create ESH, increase the availability of existing ESH, or reduce loss of existing ESH to erosion. The PDT engaged with MRRIC on the formulation and modeling of these bird alternatives.

This section summarizes the rationale and processes that occurred in formulation of bird alternatives.

The bird "test alternatives" generally consisted of modeling just one management action to facilitate understanding of the separate effects of each action on the birds and HC. These management actions included:

1. Habitat-creating reservoir release:
    - Spring release
    - Fall release

2. Reservoir water level management:
    - Oahe unbalancing or drawdown

2.7.1 Initial Iterations of Habitat-Creating Flow Releases

The effects analysis team developed relationships between water volume required to create ESH and flow magnitude (Fischenich et al. 2018). Those relationships helped determine the magnitude and duration of reservoir releases initially used to develop and model habitat-forming flow releases. Higher releases are more efficient at creating habitat over a shorter period of time because a lesser volume of stored water is required. As releases increase to more than 60 thousand of cubic feet per second (kcfs), they begin to drop in efficiency and water savings. Therefore, 60 kcfs was initially selected as the Gavins Point release for modeling habitat-forming flow releases. The Gavins Point release was supported by upstream reservoir operations. Any time a release from Gavins Point was made, a corresponding release from Garrison dam was also implemented that was approximately 17.5 kcfs less than the Gavins Point release.

Downstream flow limits and criteria are defined in the Master Manual (USACE 2006a). For purposes of formulating habitat-forming flow releases, downstream flow limits are the flows at specific downstream locations, which if exceeded, would trigger a reduction in the magnitude of the release. Downstream flow limits were set to: Omaha – 71 kcfs; Nebraska City – 82 kcfs; Kansas City – 126 kcfs. The frequency and duration of the “test alternative” releases were specified based on information developed by the effects analysis. The effects analysis models indicate flow creation is most effective when ambient (i.e., existing) ESH amounts are low. Past monitoring indicates ESH is at low levels 5–7 years after a creation event due to erosion and vegetation encroachment. Therefore, the model initiated habitat-forming flow releases if no “natural” or planned habitat-forming flow release had occurred during the preceding 7 years. Based on information from the effects analysis, these “natural” or planned habitat-forming flow releases were defined by the duration of flow required to create 500 acres of sandbar habitat and assuming 250 acres of ESH was present (Table 2-8).

A primary consideration for the timing of a habitat-forming flow release is that the amount of water that could be used for the release becomes more certain as the year progresses. In light of this consideration, two seasonal habitat-forming flow releases were developed and modeled. The first was a spring release that began on April 1 and the second a fall release that started on September 1. To conserve water in System storage, habitat-forming flow releases were modeled to only occur if the System was in the flood control zone on April 1 for the spring release and at or above “full service” (35 kcfs) on September 1 for the fall release for the initial iteration of modeling.

Initially, the duration of the planned habitat-forming flow release for the spring was based on creating 500 acres at 60 kcfs (5.5 weeks) with the assumption that 250 ESH acres were existing. For the fall, the volume of water that is in excess of what is required for “full service” through the end of the navigation season was used to calculate the highest flow (up to 60 kcfs) and duration that could be provided based on the assumption that 250 ESH acres were existing (Table 2-8). If downstream flow limits were exceeded, Gavins Point releases were reduced by 5 kcfs until the constraints were no longer exceeded and the duration for the new release, based on Table 2-8, was attempted. If Gavins Point releases fell below 45 kcfs or System storage fell below the constraints described to initiate the planned release, the habitat-forming flow release was terminated.

The initial iteration of model runs resulted in very few implemented habitat-forming flow releases over the POR due to termination of the release because downstream flow limits were exceeded or System storage fell below the flood control zones or “full-service” levels as described previously. Therefore, these initial iterations of habitat-forming flow releases were not effective at contributing towards meeting the bird habitat targets and therefore the species objectives.

2.7.2 Habitat-Forming Flow Releases Developed as Bird “Test Alternatives”

In order to assess potential for reservoir releases to create bird habitat, some of the constraints used during the initial iteration had to be relaxed. Instead of terminating the habitat-forming flow release if System storage fell below the annual flood control zones, water in the carryover-multiple use zone was used to complete the full 5.5-week duration for the spring and fall releases. This iteration of the spring release was referred to as “Spring Release A” in Table 2-9. The fall release was further revised by delaying the habitat-forming flow release until mid-October but allowing completion before the onset of ice conditions (December 1). This was referred to as “Fall Release A” in Table 2-9. These revisions to the spring and fall “test alternatives” also resulted in very few implemented habitat-forming flow releases over the POR and were not effective at contributing towards meeting the bird habitat targets.

Another iteration of the fall release was modeled that greatly relaxed the constraints by increasing the reservoir release to 70 kcfs for a duration of 8 weeks using water in the carryover multiple-use zone to complete the release. The frequency of implementing this release was also changed from as often as 7 years to 3 years if a natural or planned habitat-forming flow release had not occurred and System storage was above 31 million acre-feet (MAF). The downstream flow limits were removed to allow the full duration of the release. This iteration was referred to as “Fall Release B” in Table 2-9. The primary purpose of this fall release iteration was to see if a release could be modeled that meets bird habitat targets. This iteration of the fall release resulted in a substantial increase in ESH creation and exceeded the bird habitat targets.

Table 2-8. Flow Duration Needed to Create 500 acres of Emergent Sandbar Habitat as a Function of Existing Emergent Sandbar Habitat

Existing ESH	Duration (weeks) to meet a 500-acre (new baseline ESH) target at various discharges (kcfs)												
(acres)	45	47.5	50	52.5	55	57.5	60	62.5	65	67.5	70	72.5	75
50	22.7	14.5	10.7	8.5	7.0	6.0	5.2	4.6	4.1	3.8	3.4	3.2	2.9
100	23.1	14.8	10.9	8.6	7.1	6.0	5.3	4.7	4.2	3.8	3.5	3.2	3.0
150	23.6	15.1	11.0	8.7	7.2	6.1	5.3	4.7	4.2	3.9	3.5	3.2	3.0
200	24.2	15.3	11.2	8.9	7.3	6.2	5.4	4.8	4.3	3.9	3.6	3.3	3.1
250	24.7	15.6	11.4	9.0	7.4	6.3	5.5	4.9	4.4	4.0	3.6	3.3	3.1
300	25.3	15.9	11.6	9.1	7.5	6.4	5.6	4.9	4.4	4.0	3.7	3.4	3.1
350	25.8	16.2	11.8	9.3	7.7	6.5	5.7	5.0	4.5	4.1	3.7	3.4	3.2
400	26.5	16.5	12.0	9.4	7.8	6.6	5.7	5.1	4.6	4.1	3.8	3.5	3.2
450	27.1	16.9	12.2	9.6	7.9	6.7	5.8	5.2	4.6	4.2	3.8	3.5	3.3
500	27.8	17.2	12.5	9.8	8.0	6.8	5.9	5.2	4.7	4.3	3.9	3.6	3.3
550	28.5	17.6	12.7	9.9	8.2	6.9	6.0	5.3	4.8	4.3	3.9	3.6	3.4
600	29.2	17.9	12.9	10.1	8.3	7.0	6.1	5.4	4.8	4.4	4.0	3.7	3.4
650	30.0	18.3	13.2	10.3	8.4	7.2	6.2	5.5	4.9	4.5	4.1	3.7	3.5
700	30.9	18.7	13.4	10.5	8.6	7.3	6.3	5.6	5.0	4.5	4.1	3.8	3.5
750	31.7	19.2	13.7	10.7	8.8	7.4	6.4	5.7	5.1	4.6	4.2	3.9	3.6
800	32.7	19.6	14.0	10.9	8.9	7.5	6.5	5.8	5.2	4.7	4.3	3.9	3.6
850	33.7	20.1	14.3	11.1	9.1	7.7	6.7	5.9	5.2	4.7	4.3	4.0	3.7
900	34.7	20.6	14.6	11.3	9.3	7.8	6.8	6.0	5.3	4.8	4.4	4.1	3.7
950	35.8	21.1	14.9	11.6	9.4	8.0	6.9	6.1	5.4	4.9	4.5	4.1	3.8
1000	37.0	21.6	15.3	11.8	9.6	8.1	7.0	6.2	5.5	5.0	4.6	4.2	3.9
1050	38.3	22.2	15.6	12.1	9.8	8.3	7.1	6.3	5.6	5.1	4.6	4.3	3.9
1100	39.7	22.8	16.0	12.3	10.0	8.4	7.3	6.4	5.7	5.2	4.7	4.3	4.0
1150	41.2	23.4	16.4	12.6	10.2	8.6	7.4	6.5	5.8	5.3	4.8	4.4	4.1
1200	42.7	24.1	16.8	12.9	10.4	8.8	7.6	6.7	5.9	5.4	4.9	4.5	4.2
1250	44.4	24.8	17.2	13.2	10.7	9.0	7.7	6.8	6.1	5.5	5.0	4.6	4.2
1300	46.3	25.6	17.7	13.5	10.9	9.2	7.9	6.9	6.2	5.6	5.1	4.7	4.3
1350	48.3	26.4	18.1	13.8	11.2	9.4	8.1	7.1	6.3	5.7	5.2	4.8	4.4
1400	50.5	27.2	18.6	14.2	11.4	9.6	8.2	7.2	6.4	5.8	5.3	4.8	4.5

2.7.3 Reservoir Unbalancing "Test Alternative" (Oahe Unbalance)

An additional "test alternative" was developed to examine the potential of the reservoir water level management action. This "test alternative" exposed reservoir shoreline habitat by reducing Oahe reservoir levels 3 feet from what they would be under current operations every other year. This water would be stored in Fort Peck reservoir during years of reduced Oahe reservoir levels. This "test alternative" resulted in little additional available habitat over the POR. Table 2-9 summarizes each of the bird "test alternatives" for which HC proxy metrics were calculated and shared with MRRIC during webinars in March 2015.

Table 2-9. Bird "Test Alternatives"

Test Alternative	Reservoir System Operation
Spring Release A	• Release occurs if at full service or higher on April 1 and if natural releases creating 250 acres of ESH have not occurred in previous 7 years • Habitat-forming flow release starting April 1 of 60 kcfs • Attempt 5.5-week duration as often as every 7 years • Checks downstream flow limits (71 kcfs at Omaha, 82 kcfs at Nebraska City, 126 kcfs at Kansas City), if exceeded reduce Gavins Point releases by 5 kcfs until no longer exceeded • Increased releases from Fort Randall similar to Gavins Point and releases from Garrison were approximately 17.5 kcfs less than those from Gavins Point
Fall Release A	• Release occurs if at full service or higher on September 1 and if natural releases creating 250 acres of ESH have not occurred in previous 7 years • Habitat-forming flow release starting October 21 of 60 kcfs • Attempt 5.5-week duration as often as every 7 years • Checks downstream flow limits (71 kcfs at Omaha, 82 kcfs at Nebraska City, 126 kcfs at Kansas City), if exceeded reduce Gavins Point releases by 5 kcfs until no longer exceeded • Increased releases from Fort Randall similar to Gavins Point and releases from Garrison were approximately 17.5 kcfs less than those from Gavins Point
Oahe Unbalance	• Reduce Oahe reservoir level by 3 feet every other year • Water stored in Fort Peck during unbalancing, Garrison would float (no specific Garrison storage target as water is adjusted between Fort Peck and Oahe) • Balance upper three reservoir storage the following year
Fall Release B	• Habitat-forming flow release starting September 1 of 70 kcfs if System storage is equal to or greater than 31 MAF • 8-week duration and occurs every 3 years • Increased releases from Fort Randall similar to Gavins Point and releases from Garrison were approximately 17.5 kcfs less than those from Gavins Point

2.7.4 Round 1 Alternatives

Following the initial HC proxy webinars, the PDT began formulation of bird alternatives for use in Round 1 discussions at the May 2015 MRRIC meeting. Round 1 bird alternatives were developed with the following considerations:

- Refine the criteria governing the implementation of habitat-forming flow releases to increase their effectiveness at meeting bird habitat targets, primarily by allowing them to occur more frequently, while staying within the current operational constraints to the greatest extent possible.
- Develop and model a summer low flow management action.
- Use a combination of management actions including mechanical ESH creation to achieve the bird habitat targets.

In addition to the refinements made based on these considerations, a reduced summer low flow action was formulated and incorporated into the bird alternatives presented for Round 1. Table 2-10 describes each of the Round 1 bird alternatives for which HC proxies were calculated and presented at the May 2015 MRRIC meeting. For each Round 1 bird alternative, mechanical ESH construction was used to make up the difference between the amount of ESH created by flow actions and the amount necessary to meet the bird habitat targets.

Table 2-10. Round 1 Bird Alternatives

Alternative	Reservoir System Operation	Mechanical ESH
No Action	Current operation as defined in the Master Manual (USACE 2006a)	Approximately 164 acres/year
Mechanical ESH Creation Only	Current operation as defined in the Master Manual (USACE 2006a)	Build to meet bird targets
Spring Release B + Mechanical	• Release occurs if at full service on April 1 and if natural releases creating 250 acres of ESH have not occurred in previous 4 years • Habitat-forming flow release starting April 1 of 60 kcfs • Attempt 5.5-week duration as often as every 4 years • Checks downstream flow limits (71 kcfs at Omaha, 82 kcfs at Nebraska City, 126 kcfs at Kansas City), if exceeded reduce Gavins Point releases by 5 kcfs until no longer exceeded • Increased releases from Fort Randall similar to Gavins Point and releases from Garrison were approximately 17.5 kcfs less than those from Gavins Point	Build to meet bird targets after accounting for reservoir operations
Fall Release C + Mechanical	• Release occurs if at full service on October 15 and if natural releases creating 250 acres of ESH have not occurred in previous 4 years • Habitat-forming flow release starting October 15 of 60 kcfs • Attempt 5.5-week duration as often as every 4 years • Checks downstream flow limits (71 kcfs at Omaha, 82 kcfs at Nebraska City, 126 kcfs at Kansas City), if exceeded reduce Gavins Point releases by 5 kcfs until no longer exceeded • Increased releases from Fort Randall similar to Gavins Point and releases from Garrison were approximately 17.5 kcfs less than those from Gavins Point	Build to meet bird targets after accounting for reservoir operations

Alternative	Reservoir System Operation	Mechanical ESH
Spring Release B + Low Summer Flow + Oahe Unbalance + Mechanical	• Habitat-forming flow release as described for Spring Release B • Low summer flow of 22 kcfs from Gavins Point between May 15 and August 3 every year, during this period ignore downstream flow limits, water supply requirements, and navigation targets • Reduce Oahe reservoir level by 3 feet every other year, water stored in Fort Peck, Garrison will float, balance upper three reservoir storages the following year	Build to meet bird targets after accounting for reservoir operations
Fall Release C + Low Summer Flow + Oahe Unbalanced + Mechanical	• Habitat-forming flow release as described for Fall Release C • Low summer flow of 22 kcfs from Gavins Point between May 15 and August 3 every year, during this period ignore downstream flow limits, water supply requirements, and navigation targets • Reduce Oahe reservoir level by 3 feet every other year, water stored in Fort Peck, Garrison will float, balance upper three reservoir storages the following year	Build to meet bird targets after accounting for reservoir operations

2.7.5 Round 1 Bird Alternative Screening

Appendix A summarizes the HC proxy results for Round 1 bird alternatives. As mentioned previously, the reservoir water level management action was assessed by modeling an unbalancing of Lake Oahe. Modeling indicated that this action resulted in little additional available habitat over the POR. Bird population models showed that although this action contributed to bird populations on Lake Oahe, it resulted in a corresponding negative effect on the bird population at Lake Sakakawea due to higher reservoir levels. As a result, this management action was eliminated from further consideration because it was not effective at contributing to the bird habitat targets and in turn the species objectives. Spring and fall habitat-forming releases and low summer flows were retained for Round 2 bird alternative formulation.

2.7.6 Round 2 Alternatives

Following the May 2015 MRRIC meeting, the PDT began refining the bird alternatives for presentation at the Round 2 discussion with MRRIC. MRRIC feedback from Round 1 was considered in development of the Round 2 bird alternatives. Those MRRIC members who completed the ranking feedback forms or provided comments on the Round 1 alternatives expressed a wide range of opinions. Several MRRIC members expressed concern about the alternatives presented and their impacts on certain HCs. Others expressed support for the same alternatives. This feedback shaped the next round of model iterations in two main ways: (1) revisions to the summer low flow action were made to attempt to reduce HC impacts; and (2) continued refinement of the spring and fall ESH-creating reservoir releases to maximize effectiveness at meeting bird habitat targets and minimize HC impacts.

The PDT was unable to identify an iteration of a spring habitat-forming flow release, fall habitat-forming flow release, or a summer low flow that was effective at contributing towards meeting the bird habitat targets and could also be implemented within the operational constraints of the current Master Manual (USACE 2006a). As such, it was determined that some level of mechanical ESH construction would be required with all reservoir release and/or summer low flow actions.

The PDT refined and assessed 17 different bird alternatives for Round 2. The alternatives consisted of the No Action condition, four different spring habitat-forming flow releases, four different fall habitat-forming flow releases, and eight combinations of spring or fall habitat-forming flow releases with low summer flows. All of the fall and spring habitat-forming flow releases were modeled in combination with a low summer flow; however, only one version of a low summer flow was included for Round 2 discussion. Table 2-11 summarizes the eight Round 2 bird alternatives that were presented at the August MRRIC technical webinars.

Table 2-11. Round 2 Bird Alternatives

Alternative	Reservoir System Operation	Mechanical ESH	Retained for Plan Alternatives?
No Action	Current operation as defined in the Master Manual (USACE 2006a)	Approximately 164 acres/year	Yes
Mechanical ESH Creation Only	Current operation as defined in the Master Manual (USACE 2006a)	Build to meet bird targets	Yes
SPR_35SL + Mechanical (A32)	• Release occurs if service level is at 35 kcfs on April 1 and if natural releases creating 250 acres of ESH have not occurred in previous 4 years • Release starting April 1 of 60 kcfs • Attempt 5.5-week duration as often as every 4 years • Checks downstream flow limits (71 kcfs at Omaha, 82 kcfs at Nebraska City, 126 kcfs at KC), if exceeded reduce Gavins Point releases by 5 kcfs until no longer exceeded • Increased releases from Fort Randall similar to Gavins Point and releases from Garrison were approximately 17.5 kcfs less than those from Gavins Point	Build to meet bird targets after accounting for reservoir operations	No
SPR_42MAF + Mechanical (A30)	• Release occurs if System storage is at 42 MAF on April 1 and if natural releases creating 250 acres of ESH have not occurred in previous 4 years • Release starting April 1 of 60 kcfs • Attempt 5.5-week duration as often as every 4 years • Checks downstream flow limits (71 kcfs at Omaha, 82 kcfs at Nebraska City, 126 kcfs at KC), if exceeded reduce Gavins Point releases by 5 kcfs until no longer exceeded • Increased releases from Fort Randall similar to Gavins Point and releases from Garrison were approximately 17.5 kcfs less than those from Gavins Point	Build to meet bird targets after accounting for reservoir operations	Yes

Alternative	Reservoir System Operation	Mechanical ESH	Retained for Plan Alternatives?
SPR_31MAF + Mechanical (A29)	• Release occurs if System storage is at 31 MAF on April 1 and if natural releases creating 250 acres of ESH have not occurred in previous 4 years • Release starting April 1 of 60 kcfs • Attempt 5.5-week duration as often as every 4 years • Checks downstream flow limits (71 kcfs at Omaha, 82 kcfs at Nebraska City, 126 kcfs at KC), if exceeded reduce Gavins Point releases by 5 kcfs until no longer exceeded • Increased releases from Fort Randall similar to Gavins Point and releases from Garrison were approximately 17.5 kcfs less than those from Gavins Point	Build to meet bird targets after accounting for reservoir operations	No
FALL 35 SL + Mechanical (A28)	• Release occurs if service level is at 35 kcfs on October 17 and if natural releases creating 250 acres of ESH have not occurred in previous 4 years • Release starting October 17 of 60 kcfs • Attempt 5.5-week duration as often as every 4 years • Checks downstream flow limits (71 kcfs at Omaha, 82 kcfs at Nebraska City, 126 kcfs at KC), if exceeded reduce Gavins Point releases by 5 kcfs until no longer exceeded • Increased releases from Fort Randall similar to Gavins Point and releases from Garrison were approximately 17.5 kcfs less than those from Gavins Point	Build to meet bird targets after accounting for reservoir operations	Yes
FALL 42 MAF + Mechanical (A22)	• Release occurs if System storage is at 42 MAF on October 17 and if natural releases creating 250 acres of ESH have not occurred in previous 4 years • Release starting October 17 of 60 kcfs • Attempt 5.5-week duration as often as every 4 years • Checks downstream flow limits (71 kcfs at Omaha, 82 kcfs at Nebraska City, 126 kcfs at KC), if exceeded reduce Gavins Point releases by 5 kcfs until no longer exceeded • Increased releases from Fort Randall similar to Gavins Point and releases from Garrison were approximately 17.5 kcfs less than those from Gavins Point	Build to meet bird targets after accounting for reservoir operations	No

Alternative	Reservoir System Operation	Mechanical ESH	Retained for Plan Alternatives?
FALL 31 MAF + Mechanical (A21)	• Release occurs if System storage is at 31 MAF on October 17 and if natural releases creating 250 acres of ESH have not occurred in previous 4 years • Release starting October 17 of 60 kcfs • Attempt 5.5-week duration as often as every 4 years • Checks downstream flow limits (71 kcfs at Omaha, 82 kcfs at Nebraska City, 126 kcfs at Kansas City), if exceeded reduce Gavins Point releases by 5 kcfs until no longer exceeded • Increased releases from Fort Randall similar to Gavins Point and releases from Garrison were approximately 17.5 kcfs less than those from Gavins Point	Build to meet bird targets after accounting for reservoir operations	No
FALL 42 MAF + Low Summer Flow + Mechanical (A26)	• Release same as that in Fall 42 MAF • Low summer flow of 25 kcfs from Gavins Point between May 15 and August 3 for 2 years following habitat-creating flow events. During this period, navigation requirements are ignored.	Build to meet bird targets after accounting for reservoir operations	No

2.7.7 Round 2 Bird Alternative Screening

Numerous iterations of habitat-forming flow releases were formulated and modeled using tools developed in the effects analysis. The intent was to identify characteristics of a flow release that were most effective at contributing towards bird habitat targets while minimizing the potential for HC impacts. The iterations varied in the magnitude of the target flow, frequency of implementation, and the criteria for initiating the flow release as well as terminating it. Appendix A includes the HC proxy results for Round 2 alternatives. Model runs indicated that flow releases of less than 45 kcfs were not effective at forming ESH and a 60 kcfs flow release was the most efficient at forming ESH. Flow releases with a planned frequency of greater than 4 years were not effective at creating ESH. As a result, iterations of habitat-forming flow releases that were less than 45 kcfs or did not occur at a frequency of at least 4 years were eliminated from further consideration because they were not effective at meeting the bird habitat targets. Habitat-forming flow releases that removed downstream flow limits as a termination trigger were also eliminated from further consideration due to the adverse HC impacts that would be expected from this operational change. Likewise, habitat-forming flow releases that did not adjust the downstream flow limits to correspond with Gavins Point releases were eliminated from further consideration as they were not effective at creating ESH.

Of those bird alternatives evaluated as part of Round 2, the Spring 42 MAF plus mechanical and the Fall 35 Service Level plus mechanical alternatives were retained for development of plan alternatives. Of the fall release alternatives evaluated, Fall 35 SL and Fall 42 MAF had similar mechanical habitat construction costs; whereas Fall 31 MAF saved about $2–2.5 million. However, Fall 31 MAF presented serious concerns relative to the other fall release alternatives. Fall 31 MAF resulted in greater impacts to the reservoirs. As an example, under Fall 31 MAF a release would have been implemented in 1939 that would have lowered the elevation of Lake Sakakawea by 20 feet when the reservoir would have already been 30 feet below low pool elevation under current operations. This would lead to substantial downstream impacts in the year following the release (i.e., 1940) including a loss of 57 days of water supply at the Kansas City KCMO plant and 3 to 10 weeks of water intake losses at several major thermal power stations. Fall 31 MAF also resulted in greater negative impacts to hydropower, wastewater, and water supply intakes in the upper river relative to the other fall alternatives. As a result, USACE determined that the potential HC impacts associated with Fall 31 MAF did not offset the mechanical construction cost savings and eliminated this bird alternative from further detailed evaluation. Fall 35 SL and Fall 42 MAF had very similar construction costs; however, Fall 42 MAF resulted in greater negative impacts as determined by the HC proxies. As a result, USACE eliminated Fall 42 MAF from further evaluation because it was inferior to Fall 35 SL.

Spring 42 MAF and Spring 31 MAF resulted in similar mechanical habitat construction costs; whereas, Spring 35 SL cost about $4 to 5 million more annually. As with the fall alternatives, Spring 31 MAF resulted in substantial HC impacts in some years relative to the other spring alternatives. As a result, USACE determined that the relatively small cost savings associated with Spring 31 MAF did not outweigh the larger negative impacts to HC and eliminated it from further evaluation. Spring 42 MAF resulted in greater benefits to bird populations; however, it had greater negative impacts to certain HC. Spring 35 SL had inferior performance compared to Fall 35 SL. Therefore, USACE eliminated Spring 35 SL from further evaluation.

Modeling indicated that reduced or low summer flows improved riverine habitat in the southern region, but impacted reservoir breeding piping plover populations. While the low summer flow actions were beneficial for meeting bird habitat targets, additional habitat in the Garrison reach would be needed (above the target acreage), to compensate for impacts on reservoir habitat and to meet piping plover population objectives. Therefore, cost savings associated with implementation of a low summer flow were relatively small (about $1.2 million annually) when compared to the same alternative without a low summer flow action. The low summer flow alternative also resulted in an increased frequency of split navigation seasons, acceleration of problems at thermal power intakes, and negative impacts to other HCs including cultural resources and recreation. Relative to the same bird alternative that did not include a low summer flow action, USACE determined that there were insufficient benefits to the birds relative to negative impacts indicated by the HC proxies associated with the lower summer flow. As a result, implementation of this action as part of a Management Plan alternative evaluated in this EIS was eliminated from further consideration. However, the effects analysis indicated that there may be specific, less frequent occasions in which a low summer flow operation may be implementable within the operational constraints of the existing Master Manual. Therefore, continued research and study of this management action remains within the scope of the SAMP.

2.8 Plan Alternatives Carried Forward for Detailed Evaluation

Table 2-12 summarizes the features of each plan alternative carried forward for detailed evaluation in this MRRMP-EIS. Six plan alternatives were carried forward (the No Action alternative and five action alternatives). The names of each alternative correspond to the concept or feature that distinguishes them from all other alternatives. Some of the alternatives share management actions and these are discussed in the sections describing common actions. Actions common to Alternatives 3–6 include IRC construction, ESH construction, human restriction measures, vegetation management, science and research activities, pallid sturgeon propagation and augmentation, and monitoring. Alternatives 3–6 include the same amount of IRC construction because the amounts were designed to meet experimental design and adaptive decision criteria developed by USFWS. The amount of ESH constructed under Alternatives 3–6 is also driven by targets developed by USFWS, but amounts differ because flows would create ESH under some alternatives, decreasing the amount of ESH that would need to be mechanically constructed. The actions common to Alternatives 3–6 form the base of these alternatives. The alternatives differ in the flow-related management actions associated with them in order to clearly display the impacts of each flow action for decision-makers and the public. Alternative 3 includes a one-time flow test for a pallid sturgeon spawning cue, Alternative 4 includes a spring release to create ESH, Alternative 5 includes a fall release to create ESH, and Alternative 6 includes a new reoccurring spring release for pallid sturgeon. All of these alternatives represent different means of achieving the species objectives and allow a clear distinction between the impacts of the alternatives.

Table 2-12. Summary of Features Comprising the MRRMP-EIS Alternatives Carried Forward for Detailed Consideration

Management Actions	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Least Tern and Piping Plover						
Mechanical ESH Construction	X	X	X	X	X	X
Vegetation Management	X	X	X	X	X	X
Predator Management	X	X	X	X	X	X
Human Restriction Measures	X	X	X	X	X	X
Flow Management to Reduce Take	X	X	X	X	X	X
Spring Habitat-Creating Flow Release				X		
Fall Habitat-Creating Flow Release					X	
Monitoring and Research	X	X	X	X	X	X
Pallid Sturgeon (both Upper and Lower River)						
Propagation and Augmentation	X	X	X	X	X	X
Pallid Sturgeon Population Assessment Project	X	X	X	X	X	X
Level 1 and 2* Studies			X	X	X	X
Pallid Sturgeon: Upper River						
Monitoring and evaluation related to recruitment	X	X	X	X	X	X
Pallid Sturgeon: Lower River						
Spawning Habitat Construction			X	X	X	X
Early Life Stage Habitat Construction	X (SWH)	X (SWH)	X (IRC)	X (IRC)	X (IRC)	X (IRC)
Spawning Cue Release	X	X				X
Spawning Cue Test-Release **						
Low Summer Flow		X				
Floodplain Connectivity		X				
Habitat Development and Land Management on MRRP Lands	X	X	X	X	X	X

Source: USFWS 2003

* Note that some Level 2 studies would require additional NEPA compliance beyond the scope of this EIS.

** The test-release would only be conducted if Level 1 studies support the need.

2.8.1 Actions Common to All Plan Alternatives

The following management actions would be implemented as part of all plan alternatives carried forward for detailed evaluation in this MRRMP-EIS including the No Action alternative.

2.8.1.1 Least Tern and Piping Plover

The geographic scope of management actions for least tern and piping plover would include the Missouri River from Fort Peck Dam downstream to Ponca, Nebraska.

Mechanical ESH Construction

All alternatives include mechanical ESH construction as a management action; however, the amounts of ESH that would be created mechanically vary by alternative as described below (). Methods to implement this action under all alternatives would occur as described in Section 2.5.1.2.

Under the No Action alternative, USACE would mechanically construct ESH annually at a rate of up to 164 acres per year across the entire System. This amount is based on past average annual ESH construction in the Gavins Point Dam and upper Lewis and Clark Lake segments from 2004 through 2010. It represents continued implementation of this management action at the current level of intensity but focused in the Garrison and Gavins Point reaches. Under the No Action alternative, on average, the majority of constructed acres would occur in the Gavins Point Reach with lesser amounts of construction in the Garrison Reach. The total ESH acreage goal under this alternative would be 1,315 acres.

Under Alternative 2, USACE would mechanically construct ESH annually at an average rate of 1,331 acres per year to meet the 2003 Amended BiOp acreage goal after accounting for ESH creation resulting from flow releases under this alternative. This amount of ESH is representative of the amount that was present on the System after high releases in 1997. The total ESH acreage goal under this alternative would be 6,754 acres. The USFWS Planning Aid Letter submitted to USACE on November 5, 2015, reiterated the ESH goals included in the BiOp.

USACE would have management discretion as to how those acreage goals are achieved (i.e., mechanical construction vs. flows). USACE would approach the acreage goals under Alternative 2 incrementally, beginning with lower acreages, monitoring the bird response, and moving to higher acreages if birds are not achieving the desired biological metrics. The level of mechanical ESH construction required by Alternative 2 could not be implemented while also avoiding all potentially sensitive resources as described in Section 2.5.1.2. Under Alternative 2, on average, the majority of constructed acres would occur on the Gavins Point Reach with lesser amounts of construction occurring in the Garrison Reach, Fort Randall Reach, and Lewis and Clark Lake.

Under Alternative 3–6, mechanical construction amounts vary because this management action would be used to create enough ESH to meet bird habitat targets (described in Section 2.5.1.2) after accounting for the amount of ESH created by System operations under each alternative. Under Alternatives 3–6 the median standardized ESH targets (450 acres in the Northern Region; 1,180 acres in the Southern Region) must be met for 3 out of 4 years. Under Alternative 3, USACE would only create ESH habitat through mechanical means. Alternatives 4 and 5 include a flow release specifically intended to create ESH. Alternative 6 includes a flow release for the intended benefit of pallid sturgeon but of a magnitude that creates ESH. Therefore, because the amount of ESH created by a flow release varies by alternative, so does the amount of mechanical ESH construction needed to achieve bird habitat targets.

It is important to note that under Alternatives 3–6, ESH would not need to be constructed every year – the amount constructed in any given year is dependent on the in-river ESH trends. Table 2-13 presents the average annual ESH construction amount for years in which the bird habitat model predicted construction would be required (i.e., average ESH construction in build years). The average annual construction amount includes replacing ESH lost to erosion and vegetative growth, as well as constructing new ESH. The percent of years ESH construction is anticipated under each alternative represents the modeling results relative to how often construction would be anticipated (e.g., if the model indicated construction is required in 75 percent of years that generally equals constructing in 3 of every 4 years). The range of ESH amounts that were forecasted are represented by the 2.5 percent (low end), median (middle), and 97.5 percent (high end) values (Table 2-13). The median amount can be interpreted as the construction amount that would be exceeded in half of the years construction is required and below that amount in half of the years. Table 2-13 also presents the average annual construction rate for all years, which is the average over the modeled timeframe that includes years in which no construction occurs. This value was used to develop cost estimates presented later in this chapter. Table 2-14 shows the average distribution of constructed ESH acres by river segment based on ESH model predictions for Alternatives 3–6.

Table 2-13. Summary of Emergent Sandbar Habitat Construction by Alternative

ESH Construction	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Average ESH construction in Build Years (acres)	164	1,331	332	195	253	246
Average ESH construction in All Years (acres)	157	1,330	203	86	129	135
Percent of Years Construction Anticipated	96	100	61	44	51	55
2.5% Construction Amount (acres)	164	192	14	7	9	8
Median ESH Construction Amount (acres)	164	1,241	271	162	205	192
97.5% ESH Construction Amount (acres)	164	3,289	928	496	693	713

Table 2-14. Average Distribution of Emergent Sandbar Habitat Construction Acres by Alternative

Alternative	Gavins Point Reach	Fort Randall Reach	Garrison Reach
Alternative 3	63%	10%	28%
Alternative 4	68%	16%	16%
Alternative 5	68%	12%	20%
Alternative 6	71%	13%	16%

Vegetation Management, Predator Management, and Human Restriction Measures

Vegetation management (Section 2.5.1.6), predator management (Section 2.5.1.11), and human restriction measures (Section 2.5.1.12) would be implemented as part of all the plan alternatives including the No Action alternative.

Flow Management to Reduce Take

Flow management to reduce take as described in Section 2.5.1.10 would be implemented as part of all plan alternatives including the No Action alternative.

Monitoring and Research

USACE conducts annual productivity monitoring of least tern and piping plover populations on the reservoir and river reaches of the Missouri River Mainstem. The monitoring focuses on an adult census, measurement of fledge ratios, and documentation of incidental take. USACE also performs ESH habitat monitoring. Monitoring results are used to determine the effectiveness of management actions for least terns and piping plovers. In addition, USACE funds focused research projects on various aspects of least tern and piping plover demographics and habitat use.

2.8.1.2 Pallid Sturgeon (Both Upper and Lower River)

Propagation and Augmentation

The PSCAP as described in Section 2.5.2.3 would be implemented as part of all the plan alternatives including the No Action alternative. The Pallid Sturgeon Recovery Team and Basin Workgroups undertake annual reviews of data to ensure timely updates to stocking plans in the upper and lower river (e.g., USFWS 2007). A new Pallid Sturgeon Propagation Plan is being developed by the Pallid Sturgeon Recovery Team because of important concerns related to fish health/disease, genetics, stocking size, stocking practices, etc. This propagation plan will examine hatchery practices and recommend changes to rearing practices to minimize disease occurrences and ensure appropriate levels of production. The plan will also address issues related to obtaining appropriate genetic representation in the stocked population. The USFWS plan will focus on hatchery practices, rather than the fate of fish after release from the hatchery. The authority and responsibility for hatchery management lie with USFWS for those facilities operated by USFWS; states are responsible for the operation of their hatcheries. USACE support of pallid sturgeon propagation and augmentation efforts would continue at current levels under all plan alternatives. USACE's primary method of support is through the provision of annual funding, which is anticipated to continue at approximately $455,000 annually, but is subject to change based on yearly budget appropriations.

Pallid Sturgeon Population Assessment Project

The Pallid Sturgeon Population Assessment Project (PSPAP) has been the primary fish monitoring element for the BiOp and the MRRP and would continue in some form under all plan alternatives including the No Action alternative. Data collected through the PSPAP are used to evaluate the PSCAP and provide long-term assessment of fish metrics. USACE is responsible for ensuring that these long-term assessment activities occur to meet BiOp required monitoring and evaluation. USACE has developed partnerships with state and federal agencies already active on the Missouri and Kansas Rivers and has provided the funding, standardized protocols, and quality control oversight necessary to implement the monitoring strategy of the PSPAP. Some level of redesign of the PSPAP is anticipated in the future in order to achieve efficiencies and align the PSPAP to help evaluate management hypotheses.

2.8.1.3 Pallid Sturgeon: Upper River

Monitoring and Evaluation of Recruitment

Under all plan alternatives, USACE would conduct the monitoring and assessment complimentary of that for which the Bureau of Reclamation has responsibility to determine if modifications for fish passage at Intake Diversion Dam are meeting pallid sturgeon objectives. The Bureau of Reclamation is responsible for monitoring the success of fish passage at Intake following implementation of fish passage measures. USACE would be responsible for ensuring that MRRP monitoring and assessment can determine if successful fish passage at Intake is contributing to the upper river pallid sturgeon population.

2.8.1.4 Pallid Sturgeon: Lower River

Unless stated otherwise, the geographic scope of management actions to benefit pallid sturgeon in the lower Missouri River is downstream of Gavins Point Dam to the confluence of the Missouri and Mississippi Rivers near St. Louis.

Early Life Stage Habitat Construction

All plan alternatives include channel reconfiguration for the creation of early life stage pallid sturgeon habitat; however, the amounts and types of habitat that would be created vary by alternative and those differences are described in the respective section for each alternative. Methods to implement this action may include any of those described in Section 2.5.3.1.

Habitat Development and Land Management on MRRP Lands

All plan alternatives include habitat development on MRRP lands; however, the amount of land acquisition varies by alternative and so would the magnitude of the action. Those differences are described in the respective section for each alternative. Methods to implement this action are described in Section 2.5.4.

2.8.2 Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)

Under Alternative 1, the MRRP would continue to be implemented as it is currently. The following sections describe the actions that would be taken towards BiOp compliance in addition to those common actions identified in Section 2.8.1 and their projected level of intensity as part of Alternative 1.

2.8.2.1 Least Tern and Piping Plover

Under Alternative 1, no additional management actions other than those described in Section 2.8.1 would be implemented in compliance with the BiOp for least tern and piping plover on the Missouri River.

2.8.2.2 Pallid Sturgeon – Lower River

Under Alternative 1, the following management actions would be implemented in compliance with the BiOp for pallid sturgeon in the lower Missouri River in addition to those described in Section 2.8.1.

Early Life Stage Habitat Construction

Under Alternative 1, construction of habitat to support early life stage requirements of pallid sturgeon would occur as part of the SWH program. The SWH restoration goal as outlined in the 2003 Amended BiOp (USFWS 2003) is to achieve an average of 20–30 acres of SWH per river mile. Under Alternative 1, USACE would achieve the low end of this acreage target (i.e., 20 acres per river mile between Ponca, Nebraska, and the mouth). This equates to a total of 15,060 acres of SWH. Existing habitat on the System combined with SWH projects have created a total of 11,832 acres, leaving 3,999 acres to be created (Table 2-15). For purposes of evaluating potential impacts to the human environment, modeling assumed that the additional SWH acreage would be created as follows (Table 2-16):

- Approximately 3,519 acres of in-channel SWH created through channel or top-width widening. A conceptual width of 250 feet was assumed for projects between Ponca and Rulo (20 projects encompassing 48 river miles) and 300 feet for projects downstream of Rulo (24 projects encompassing 57 river miles). Actual project width and size will vary by site.
- Approximately 480 acres of off-channel backwaters, assuming 8 new backwaters with each creating 60 acres of SWH.

Table 2-15. Summary of Projected Shallow Water Habitat Creation Under Alternative 1

River Reach	River Mile Start	River Mile End	Miles in Reach	20 acres per mile of SWH	Existing acres of SWH*	Target Acres of SWH
Ponca to Sioux City	753	735	18	360	120	240
Sioux City to Platte River	735	595	140	2,800	1,779	1,021
Platte River to Rulo	595	498	97	1,940	1,268	672
Rulo to Kansas River	498	367	131	2,620	1,491	1,129
Kansas River to Osage River	367	130	237	4,740	3,803	937
Osage River to Mouth	130	0	130	2,600	3,371	0
		Total	**753**	**15,060**	**11,832**	**3,999**

*Reflects SWH projects constructed as of the end of 2015

Table 2-16. Projected Composition of Shallow Water Habitat Creation Type Under Alternative 1

River Reach	Target Acres of SWH	Channel Widening[a]			Backwaters[b]	
		Acres	Miles	# of Projects	Acres	# of Projects
Ponca to Sioux City	240	180	5.9	2	60	1
Sioux City to Platte River	1,021	601	19.8	9	420	7
Platte River to Rulo	672	672	22.2	9	0	0
Rulo to Kansas River	1,129	1,129	31.1	14	0	0
Kansas River to Osage River	937	937	25.8	10	0	0
Osage River to Mouth	0	0	0	0	0	0
Total	**3,999**	**3,519**	**105**	**44**	**480**	**8**

a Acreage amounts assume a top width of 250 feet for projects between Ponca and Rulo and 300 feet for projects downstream of Rulo.

b Assumes 60 acres of SWH are created by each project.

Assumptions associated with SWH acreages are documented in the HEC-RAS modeling reports (www.moriverrecovery.org). Table 2-17 summarizes the amount of land acquisition that was assumed to be required to implement the identified amount of SWH.

Table 2-17. Land Acquisition Requirements to Implement Early Life Stage Pallid Sturgeon Habitat Under Alternative 1

River Reach	Target Acres of SWH	Additional Land Required: Habitat Only (acres)[a]	Additional Land Required: Total (acres)[b]
Ponca to Sioux City	240	240	1,848
Sioux City to Platte River	1,021	0	0
Platte River to Rulo	672	0	0
Rulo to Kansas River	1,129	675	5,198
Kansas River to Osage River	937	0	0
Osage River to Mouth	0	0	0
Total	**3,999**	**915**	**7,046**

a Additional land requirements was determined by assessing if there were existing public lands (i.e., USACE, USFWS, or state conservation lands) within each river reach that may be appropriate for habitat development. If this value is zero it means that either there were no habitat targets within this reach for the alternative or the assessment determined that there was potential to achieve the habitat targets on existing public lands. These areas do not necessarily represent actual locations of future habitat development.

b For estimating purposes, it was assumed that 7.7 acres of land acquisition are required for every 1 acre of habitat needed. This is based on historic implementation data and accounts for factors such as parcel size and other real estate acquisition considerations.

Spawning Cue Release

For purposes of modeling Alternative 1, USACE assumed continued implementation of the plenary spring pulse as described in the Master Manual (USACE 2006a). It was also assumed that reservoir unbalancing as described in the Master Manual would not be implemented. The bimodal Gavins Point spring pulse plan was developed based on the following: the provisions of the 2003 Amended BiOp (USFWS 2003) including the Integrated Science Program (ISP), input from the 2005 spring pulse Plenary Group and its technical working groups, and Tribal consultations/meetings and public comments received on the draft spring pulse plan presented in the fall of 2005. A description of the detailed features of the plan follows.

Gavins Point Spring Pulse Downstream Flows Limits: The magnitude of both the March and May Gavins Point spring pulses would be constrained by the Gavins Point spring pulse downstream flow limits. These downstream flow limits are established at the same locations as the current downstream flow limits discussed in the Master Manual (USACE 2006a) and shown in Table 2-18. The downstream flow limits shown in Table 2-18 are the same values as the most conservative downstream flow limits and therefore, would provide similar downstream flood control during the spring pulse periods. As an additional precaution, radar detected precipitation and National Weather Service quantitative precipitation forecasted would continue to be used in forecasting the resultant downstream flows. Gavins Point releases would be adjusted as required during the spring pulse periods based on this forecast.

Table 2-18. Downstream Flow Limits During the Spring Pulse Under Alternative 1

Location	Flow Limit (cfs)
Omaha	41,000
Nebraska City	47,000
Kansas City	71,000

March Spring Pulse from Gavins Point: The March spring pulse below Gavins Point would depend on System storage. If the actual System storage as computed on March 1 is at or below 40.0 MAF, a March pulse would not be implemented. The magnitude of the March pulse is defined as the combination of the Gavins Point release increase and the contribution of the James River. Assuming that System storage is above 40.0 MAF, the magnitude of the March pulse would be 5,000 cfs and would be implemented the day after System releases reach the level necessary to provide downstream flow support for the beginning of the navigation season. More specifically, the magnitude of the Gavins Point release at the peak of the March pulse would be 5,000 cfs minus the contribution of the James River measured at the Scotland, South Dakota, stream gage. Actual releases from Gavins Point Dam would be set to the nearest 500 cfs increment. Also, the total Gavins Point release during the March pulse would not be set any higher than the Gavins Point power plant capacity (35,000 cfs). The duration of the peak of the March pulse would be 2 days. Following the 2-day peak, the March pulse flows would be reduced each day over the next 5 days until non-spring pulse downstream flow support rates are achieved.

May Spring Pulse from Gavins Point: The May spring pulse from Gavins Point would depend on actual System storage as computed on May 1. If the actual System storage as computed on May 1 is at or below 40.0 MAF, a May pulse would not be implemented. The magnitude of the May pulse, as is the case for the March pulse, is defined as the combination of Gavins Point release increase and the contribution of the James River. Therefore, the magnitude of the Gavins Point release at the peak of the May pulse would be the result of the two-step proration computation described below minus the contribution of the James River measured at the Scotland, South Dakota, stream gage. The total Gavins Point release during the May pulse would not be constrained to the Gavins Point powerplant capacity, as is the case for the March pulse. The two-step proration computation to determine the magnitude of the May pulse is as follows:

1. First Step: The May pulse magnitude is first computed based on May 1 System storage. The May pulse magnitude is prorated in a straight-line interpolation between 16,000 cfs and 12,000 cfs based on a System storage range between 54.5 and 40 MAF. The May pulse magnitude in this step is limited to 16,000 cfs if System storage is greater than 54.5 MAF. For the initial occurrence of the May pulse, if System storage is between 36.5 and 40 MAF, the resultant magnitude from this step is 12,000 cfs.
2. Second Step: The resultant May pulse magnitude from the first step is then further prorated based on USACE's May 1, Mainstem Calendar Year Runoff Forecast for the Missouri River basin above Sioux City, Iowa. The May pulse magnitude computed in the first step could be decreased or increased by as much as 25 percent in this step. The May pulse magnitude resulting from the first step is increased in a straight-line interpolation from 0 to 25 percent for a calendar year runoff forecast that ranges from median to upper quartile. The May pulse magnitude from the first step is decreased in a straight-line interpolation from 0 to 25 percent for a May 1 calendar year runoff forecast that ranges from median to lower quartile runoff. Use of both steps in this computational process produces a potential range of May pulse magnitudes from 9,000 cfs to 20,000 cfs. Actual releases from Gavins Point Dam would be set to the nearest 500 cfs increment.

The initiation of the May pulse would be between May 1 and May 19, depending on Missouri River water temperature measured immediately below Gavins Point Dam. The May pulse would be initiated after the second daily occurrence of a 16°C or higher Missouri River water temperature. However, the final decision on the date of the initiation of the May pulse would take into account the potential for "take" of threatened and endangered bird species during the pulse period and downstream flow conditions.

Gavins Point releases would be increased at a rate of approximately 6,000 cfs per day from normal downstream flow support releases until the full May pulse magnitude, as calculated previously, is achieved. The May pulse magnitude would be maintained for 2 days, after which releases would be decreased by 30 percent over the following 2 days. The remaining release reductions would be prorated over an additional 8 days until non-spring pulse downstream flow support rates are achieved. This would result in a recession length of 10 days from the peak of the May pulse. The length and magnitude of the recession may also be constrained by the downstream flow limits shown in Table 2-18.

Monitoring and Research

Pallid sturgeon science efforts require a comprehensive approach to provide information to decision-makers. USACE management actions require riverine monitoring to determine the species response, or effectiveness of the action, and any unintended effects. These assessments are further developed through research activities to clarify critical uncertainties. Research activities focus on factors limiting recruitment. These elements, in combination with propagation and augmentation, seek to identify and remove bottlenecks to pallid sturgeon recruitment. Under Alternative 1, the following monitoring and research activities would continue in addition to the PSPAP, which is common to all plan alternatives.

- **Habitat Assessment and Monitoring Program**: The Habitat Assessment and Monitoring Program began in 2004 and was developed by representatives of state and federal agencies and academia that collectively possess knowledge and expertise on the Missouri River, pallid sturgeon and other native Missouri River fishes, research, experimental design, and statistical analysis. The Habitat Assessment and Monitoring Program focuses on the endangered pallid sturgeon, other big river native fishes, and their habitats as recommended by the BiOp. The goal of the Habitat Assessment and Monitoring Program is to assess the physical and biological responses to habitat creation actions that are expected to benefit pallid sturgeon and related fish communities.
- **Focused Pallid Sturgeon Research**: USACE annually funds focused research to address remaining critical pallid sturgeon information gaps including the identification and better understanding of key pallid sturgeon life stage transitions and development of explicit pallid sturgeon objectives and prioritized hypotheses.

2.8.2.3 Adaptive Management

Under Alternative 1, USACE would continue to implement the AM approach that has been in place since 2009. It consists of two primary components: the SAMP for ESH (USACE 2011) and the AM strategy developed for SWH creation (USACE 2012c). The AM approach developed for the SWH and ESH sub-programs was developed in accordance with the 2000 BiOp and the 2003 amended BiOp, which called 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, USACE released a technical memorandum describing implementation guidance for Section 2039 of the WRDA 2007, which called for monitoring and AM of ecosystem restoration projects and provided some specific direction on what should be addressed within AM plans. Finally, the National Research Council (NRC) called for AM efforts in their 2002 report *The Missouri River Ecosystem: Exploring the Prospects for Recovery* (NRC 2002). In 2008, a multi-agency team consisting of representatives from USACE, USFWS, NPS, and experts in structured decision-making and model development initiated strategy development. In 2009, the strategy was updated by the MRRP Adaptive Management Work Group and the ESH Programmatic Environmental Impact Statement PDT in coordination with cooperating agencies on the Programmatic Environmental Impact Statement (i.e., USFWS and NPS) before finalization and implementation in 2010.

Monitoring data would be compiled and analyzed on an annual basis to assess progress towards stated objectives for both ESH and SWH and to report results. These annual reports would include recommendations related to all or some of the following program decisions: (1) level of construction effort, (2) pilot projects, (3) site adjustments, (4) incorporation of new methodologies, and (5) investigations. Every 5 years, additional analyses would be conducted in order to assess whether the elements of the ESH AM Plan and SWH AM strategy are being met. If a decision is made to update the ESH AM Plan or SWH AM strategy document, a scope, schedule, and plan of action would be developed.

MRRIC and other groups may choose to provide comments or recommend adjustments to AM strategies at any time during the implementation process. This could include changes to AM objectives, incorporation of additional management actions, input on anticipated benefits and tradeoffs, and other pertinent elements of the AM plans. For additional detail regarding the AM framework that would be followed under Alternative 1, see the MRRP Adaptive Management

Framework, ESH AM Plan, and SWH AM Strategy, which are public documents available on the MRRP website at www.moriverrecovery.org.

2.8.3 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 represents USFWS's interpretation of the management actions that would be implemented as part of the 2003 Amended BiOp RPA (USFWS 2003). Whereas the No Action alternative only includes the continuation of management actions USACE has implemented to date for BiOp compliance, Alternative 2 includes additional iterative actions and expected actions that USFWS anticipates would ultimately be implemented through AM and as impediments to implementation were removed. The following sections describe the actions that would be taken towards BiOp compliance and their projected level of intensity as part of USFWS's 2003 BiOp Projected Actions alternative. USFWS input on this alternative was formalized in a Planning Aid Letter submitted to USACE on November 5, 2015.

2.8.3.1 Least Tern and Piping Plover

Under Alternative 2, the following management actions would be implemented in compliance with the 2003 Amended BiOp (USFWS 2003) for least tern and piping plover on the Missouri River. These actions would be in addition to those described in Section 2.8.1.1.

Spring Habitat-Forming Flow Release

A spring reservoir release for the purposes of ESH creation is not included in Alternative 2. However, the timing and magnitude of the pallid sturgeon spawning cue release would provide ESH creating benefits. These benefits are accounted for in the habitat availability modeling that determined the amount of ESH that would be mechanically created (Section 2.8.1.1).

Lowered Nesting Season Flow

The low summer flow described for pallid sturgeon would also serve as a lowered nesting season flow for the benefit of least terns and piping plovers under Alternative 2. The criteria for the flow implementation would be the same as described in Section 2.8.3.2.

2.8.3.2 Pallid Sturgeon – Lower River

Under Alternative 2, the following management actions would be implemented in compliance with the BiOp for pallid sturgeon in the lower Missouri River. These actions would be in addition to those described in Section 2.8.1.2.

Early Life Stage Habitat Construction

Under Alternative 2, construction of habitat to support early life stage requirements of pallid sturgeon would occur as part of the SWH program. The SWH restoration goal as outlined in the 2003 Amended BiOp (USFWS 2003) is to achieve an average of 20–30 acres of SWH per river mile. Under Alternative 2, USACE would achieve the upper end of this acreage target (i.e., 30 acres per river mile between Ponca, Nebraska, and the mouth). This equates to a total of 22,590 acres of SWH. Existing SWH projects have created a total of 11,832 acres, leaving 10,758 acres to be created (Table 2-19). For the purposes of evaluating potential impacts to the human environment, modeling assumed that the additional SWH acreage would be created as follows (Table 2-20):

- Approximately 9,858 acres of in-channel SWH would be created through channel widening. A conceptual width of 250 feet was assumed for projects between Ponca and Rulo (60 projects encompassing 118.2 river miles) and 450 feet for projects downstream of Rulo (48 projects encompassing 115 river miles). Actual project width and size will vary by site.
- Approximately 900 acres of off-channel backwaters, assuming 15 new backwaters with each creating 60 acres of SWH.

Land acquisition to implement the SWH requirements described is summarized in Table 2-21.

Table 2-19. Summary of Projected Shallow Water Habitat Creation Under Alternative 2

River Reach	River Mile Start	River Mile End	Miles in Reach	30 acres per mile of SWH	Existing acres of SWH	Target Acres of SWH
Ponca to Sioux City	753	735	18	540	120	420
Sioux City to Platte River Confluence	735	595	140	4,200	1,779	2,421
Platte River Confluence to Rulo	595	498	97	2,910	1,268	1,642
Rulo to Kansas River Confluence	498	367	131	3,930	1,491	2,439
Kansas River Confluence to Osage River Confluence	367	130	237	7,110	3,803	3,307
Osage River Confluence to Mississippi River Confluence	130	0	130	3,900	3,371	529
		Total	**753**	**22,590**	**11,832**	**10,758**

Table 2-20. Projected Composition of Shallow Water Habitat Creation Type Under Alternative 2

River Reach	Target Acres of SWH	Channel Widening[a]			Backwaters[b]	
		Acres	Miles	# of Projects	Acres	# of Projects
Ponca to Sioux City	420	240	7.9	4	180	3
Sioux City to Platte River	2,421	1,761	58.1	32	660	11
Platte River to Rulo	1,642	1,582	52.2	24	60	1
Rulo to Kansas River	2,439	2,439	44.7	19	0	0
Kansas River to Osage River	3,307	3,307	60.6	25	0	0
Osage River to Mouth	529	529	9.7	4	0	0
Total	**10,758**	**9,858**	**233**	**108**	**900**	**15**

a Acreage amounts assume a top width of 250 feet for projects between Ponca and Rulo and 450 feet for projects downstream of Rulo.

b Assumes 60 acres of SWH are created by each project.

Table 2-21. Land Acquisition Requirements to Implement Early Life Stage Pallid Sturgeon Habitat Under Alternative 2

River Reach	Target Acres of SWH	Additional Land Required: Habitat Only (acres)[a]	Additional Land Required: Total (acres)[b]
Ponca to Sioux City	420	420	3,234
Sioux City to Platte River	2,421	925	7,123
Platte River to Rulo	1,642	675	5,198
Rulo to Kansas River	2,439	1,985	15,285
Kansas River to Osage River	3,307	1,932	14,876
Osage River to Mouth	529	0	0
Total	**10,758**	**5,937**	**45,716**

a Additional land requirements was determined by assessing if there were existing public lands (i.e., USACE, USFWS, or state conservation lands) within each river reach that may be appropriate for habitat development. If this value is zero it means that either there were no habitat targets within this reach for the alternative or the assessment determined that there was potential to achieve the habitat targets on existing public lands. These areas do not necessarily represent actual locations of future habitat development.

b For estimating purposes, it was assumed that 7.7 acres of land acquisition are required for every 1 acre of habitat needed. This is based on historic implementation data and accounts for factors such as parcel size and other real estate acquisition considerations.

Spring Pallid Sturgeon Flow Release

USFWS determined in the 2003 Amended BiOp (USFWS 2003) that restoration of a normalized river hydrograph below Gavins Point Dam was necessary to avoid a finding of jeopardy to the pallid sturgeon. Several biologically relevant features were identified for a flow action below Gavins Point Dam including (1) flows to cue spawning that are sufficiently high for an adequate duration; and (2) flows that provide for connection of low-lying lands adjacent to the channel.

The spring pallid sturgeon flow release from Gavins Point Dam would be bimodal (i.e., consisting of two separate flow pulses) and would be implemented in every year if conditions are met. If System storage on March 15 is 31.0 MAF or less, equating to a “no service” navigation year, the spawning cue release would not be implemented. In addition, if downstream flood control targets are exceeded the spawning cue release would not be initiated or it would be terminated if these targets are exceeded during implementation. The results of preliminary reservoir simulation modeling based on the POR, indicate that in practice the bimodal spring pallid sturgeon flow releases would likely only meet the conditions for implementation once every 20 years. The conditions and characteristics of the two pulses would include:

- In advance of the first pulse, the maximum winter Gavins Point release would be maintained at 16 kcfs.
- First pulse from Gavins Point Dam.
    - Implementation would occur if the conditions described previously are met, System storage on March 1 is at least 40.0 MAF, and the System is not at storage evacuation service level on March 15.
    - Implementation would begin with the typical increase in flow to provide for navigation around March 15.

- The rate of flow increase (i.e., the ascending limb of the pulse) would last 7 days until a peak of 31 kcfs is reached.
- Once reached, the peak flow would be maintained for 7 days. After that, the rate of decrease (i.e., the descending limb of the pulse) would last 7 days and then return to flow-to-target operations based on service level from March 15 storage check. Flow-to-target means that reservoir operations are adjusted daily to meet downstream navigation targets.

- Second pulse from Gavins Point Dam.
  - Implementation would occur if the conditions described previously are met and System storage on May 1 is at least 40.0 MAF. Downstream flow limits would be determined by adding the pulse magnitude to the existing downstream flow limits as shown in Table VII-7 and VII-8 in Master Manual (USACE 2006a). For example, if the pulse magnitude is 16 kcfs and the flood targets are 41 kcfs, 47 kcfs, and 71 kcfs at Omaha, Nebraska City, and Kansas City, respectively, the downstream flow limits would be 57 kcfs at Omaha (16 kcfs + 41 kcfs), 62 kcfs at Nebraska City (16 kcfs + 47 kcfs), and 87 kcfs at Kansas City (16 kcfs + 71 kcfs). The pulse would be terminated any time downstream flow limits are exceeded.
  - Implementation would begin on May 1.
  - The rate of flow increase (i.e., the ascending limb of the pulse) would last 7–10 days.
  - The pulse peak would be based on the March 1 forecast as follows but would never exceed a total Gavins Point Dam release of 60 kcfs:
    - Lower quartile or lower runoff = 12 kcfs rise over May 1 release and maintained for 14 days
    - Median = 16 kcfs rise over May 1 release and maintained for 25 days
    - Upper quartile or higher runoff = 20 kcfs rise over May 1 release and maintained for 35 days
  - The rate of decrease (i.e., the descending limb of the pulse) would last not less than 7 days until a return to “steady release” scenario is reached.

Low Summer Flow

The USFWS 2003 Amended BiOp (USFWS 2003) also called for modification to System operations to allow for flows that are sufficiently low to provide for SWH as rearing, refugia, and foraging areas for larval, juvenile, and adult pallid sturgeon. Alternative 2 includes a low summer flow that would be implemented as follows:

- Summer low flow would only be implemented in the 2 years following implementation of a complete bimodal spring pallid sturgeon flow release, meaning that both the first and second pulses are implemented completely.
- From June 23 to July 1, Gavins Point Dam release would be set to 25 kcfs
- On July 1, USACE would assess the navigation season length and operate as follows:
  - If there is a shortened navigation season as determined by the existing Master Manual (USACE 2006a):

- Gavins Point Dam releases would be determined based on meeting water supply targets (open channel non-navigation season).
- The duration of those releases would be equivalent to that of the number of days the season is shortened less the 8 days in June (e.g., if season is shortened 30 days).
- Following that duration, flows would be set to 25 kcfs until July 15 at which time release would be dropped to 21 kcfs until August 15. As of August 15, releases would return to 25 kcfs until September 1.
- Flow-to-target operations would resume from September 1 until December 1.

- If there is not a shortened navigation season:
  - Releases of 25 kcfs would continue from July 1 to July 15 then drop to 21 kcfs until August 15. After August 15, releases would return to 25 kcfs until September 1.
  - Flow-to-target operations would resume from September 1 until December 1 or December 10 if a 10-day navigation season extension is determined.

Floodplain Connectivity

The USFWS 2003 Amended BiOp (USFWS 2003) stated the following in regard to floodplain connectivity:

> Floodplain inundation and connectivity is essential in order to maximize the production of the forage base for pallid sturgeon. The forage base production must occur at a time that coincides with larval sturgeon becoming active, free-swimming feeders. Floodplains are highly productive habitat in the late spring and early summer when warm, shallow water floods over the area and produces a bloom of forage that is of appropriate size for larval fish to eat. Additionally, low-lying lands are an extremely important source for floodplain spawning fish, which subsequently support the forage base for adult pallid sturgeon. Highly productive floodplains are necessary on a frequent annual basis to provide necessary life requisites for pallid sturgeon survival.

USACE coordinated with USFWS during development of Alternative 2 to identify criteria for clarification of the above floodplain connectivity language from the 2003 BiOp. The 2003 BiOp did not contain numeric criteria for floodplain connectivity. USFWS provided these criteria in a Planning Aid Letter submitted to USACE on November 5, 2015. The criteria stated that the management action should maximize floodplain habitat by ensuring that 77,410 acres of connected floodplain are inundated at a 20 percent annual chance exceedance. This acreage amount was an interpretation, made in 2015, of the above language from the 2003 BiOp developed to inform alternatives development. USACE conducted HEC-GeoRAS mapping to determine the acres of existing floodplain connectivity in the lower Missouri River. This was the first time this type of an analysis had been done. The mapping results indicated that 147,650 acres of floodplain connectivity are currently present, not including the area of the main channel. Under Alternative 2, it is assumed that normal operations combined with tributary inflow would result in floodplain connectivity of at least 77,410 acres as indicated by the mapping results described previously, thus no additional action would be required. This analysis should not be interpreted to indicate that floodplain connectivity has increased from 77,410 acres to 147,650 acres from 2003 to present. Only that current normal operations combined with tributary inflow are meeting numeric criteria for floodplain connectivity developed by USFWS in 2015.

Monitoring and Research

Monitoring and research efforts under Alternative 2 would be the same as described for Alternative 1.

2.8.3.3 Adaptive Management

The AM approach for Alternative 2, is similar to the AM approach that USACE has been implementing since 2009 and described for Alternative 1. The AM approach for Alternative 2 would be the same as for Alternative 1 but would be modified to address specific alterations in proposed management actions as described in the November 5, 2015, Planning Aid Letter from USFWS. Management actions implemented by USACE as part of Alternative 2 would be modified and continually improved upon through AM and in cooperation with USFWS. Due to changing river conditions, methods of implementing management actions may vary over time, and modifications to management actions would be based on an evaluation of habitat, flow, climate, species response, and any other new information available each year. Under Alternative 2, monitoring would be a key component to the AM approach to document how management actions were implemented and their effects within the river and on the listed species. USACE and USFWS would jointly define what is considered to be sufficient progress for each management action within specified timeframes to avoid a finding of jeopardy.

2.8.4 Alternative 3 – Mechanical Construction Only

Under Alternative 3, current System operations as described in the Master Manual would continue except the spring plenary pulse and reservoir unbalancing would not be implemented. The following management actions are included under Alternative 3 in addition to those common actions identified in Section 2.8.1. Anticipated levels of mechanical ESH construction are shown in Table 2-13.

2.8.4.1 Adaptive Management

Under Alternative 3, USACE would follow the SAMP that was developed based on the results of the Effects Analysis. The SAMP is a companion document to the MRRMP-EIS. The SAMP identifies the process and criteria to implement the initial management actions, assess hypotheses, introduce new science, and provide a process for adjusting management actions should it become necessary. The SAMP provides a management framework for pallid sturgeon in the upper and lower river segments that includes a hierarchical design of scientific studies and management actions aimed at addressing uncertainties about factors limiting pallid sturgeon natural recruitment. The SAMP also includes a management framework for piping plovers and least terns consisting of a program of habitat construction, monitoring, and research activities. The SAMP was designed to address uncertainty related to management for the species and meet updated species objectives that were developed based on results of the effects analysis.

The role of AM in MRRP least tern and piping plover management is to improve decision-making in light of uncertain future trends in habitat availability and improved understanding of various management actions. As the AM program is implemented, what is learned about the actions included within its scope will be applied to increase their effectiveness, and may also result in the addition or removal of management actions from consideration. For pallid sturgeon, lingering uncertainties regarding the scope and scale of the management actions necessary to address recruitment failure has led to an AM framework reliant upon a progressive AM approach to manage risks to the pallid sturgeon. Under Alternative 3, the AM strategy is driven by the hypotheses generated by the effects analysis effort. For additional detail about the AM Framework, see Chapter 4 and the full SAMP that accompanies the MRRMP-EIS (www.moriverrecovery.org).

2.8.4.2 Level 1 and 2 Studies

As part of the AM program described previously, USACE would implement Level 1 and 2 studies under Alternative 3 for better understanding of limiting factors associated with pallid sturgeon. Level 1 studies are research focused and do not change the System (laboratory studies or field studies under ambient conditions). Level 2 studies would focus on in-river testing of actions at a level sufficient to expect a measurable biological, behavioral, or physiological response in pallid sturgeon, surrogate species, or related habitat response. For example, Level 2 studies would include a one-time spawning cue test release from Gavins Point if Level 1 studies during the first 9–10 years support the need for a managed pulse from Gavins Point Dam. At the present time, it is assumed the test release would be similar to the timing, magnitude, duration, and pattern of the spawning cue included as a recurring release under Alternative 6. If determined to be necessary following 9–10 years of Level 1 studies, the test release would be implemented in accordance with the rules described for Alternative 6. For additional information on the types of studies that could be implemented under Alternative 3 see Chapter 4 and the SAMP (www.moriverrecovery.org).

2.8.4.3 Spawning Habitat Construction

Under Alternative 3, USACE would construct up to three high-quality spawning habitat sites, and monitor the effectiveness of this action in terms of the relative use of these sites compared to other control areas, and the relative spawning success, as determined by hatch rate, catch per unit effort of free embryos, and other indicators. Sufficient understanding to characterize the necessary features of high quality pallid sturgeon spawning habitat does not exist. These sites would be constructed following initial studies to further clarify habitat specifications. An early emphasis would use information from the Yellowstone River as the best natural reference condition to inform the design of these pilot projects on the lower Missouri River, while also continuing to examine the habitat characteristics of spawning sites on the lower Missouri River.

2.8.4.4 Early Life Stage Habitat Construction

Under Alternative 3, construction of habitat to support early life stage requirements of pallid sturgeon would occur following the IRC (interception and rearing complexes) concept. Consistent with the Planning Aid Letter provided by USFWS September 14, 2016 (Appendix B), USACE would modify twelve river bends to create IRC habitat. It is anticipated that these twelve projects would be constructed downstream of RM 321, the uppermost location where an age-0 pallid sturgeon has been captured, ensuring IRC projects are co-located in the reach of river that is most likely to harbor age-0 pallid sturgeon transitioning from drifting free embryos to the benthic feeding stage. While the emphasis of the design, construction, and monitoring of these sites is to better understand constructability, function, and biological response, it is estimated that these twelve sites would meet the habitat targets for this time period as described in

USFWS's Planning Aid Letter dated September 14, 2016. If results remain equivocal following this experiment, additional field experiments would be implemented to resolve uncertainties regarding the importance of IRC habitat to the survival of age-0 sturgeon in an expedited manner. Table 2-22 provides the rate and time frame for IRC habitat construction and would contribute to the Level 3 habitat targets described in the Planning Aid Letter provided by USFWS September 14, 2016 (Appendix B). There is currently a lack of quantitative functional relationships that translate IRC habitat amounts to any pallid sturgeon population parameters. If not resolved through the adaptive management process this could hinder determination of how much IRC habitat needs to be constructed in order to generate a measurable population response for pallid sturgeon. Appendix C of the SAMP addresses the strategy to move from IRC characteristics to growth and survival demographic parameters.

Table 2-22. Rate and Time Frame of Interception Rearing Complex Habitat Construction

Action Category	Time Limit	Scope
IRC habitat development	Stage 1: study phase (years 1–3 post-ROD)	Build 2 IRC sites per year (paired with control sites), adding 33,000 ac-d/yr of suitable habitat, using staircase design. Assess potential for refurbishing existing SWH sites as IRCs
	Stage 2: continue study phase (years 4–6 post-ROD)	Build 2 IRC sites per year (paired with control sites), adding 33,000 ac-d/yr of suitable habitat. Refurbish SWH sites in addition to study sites.
	Stage 3: Level 3 implementation (years 7–10 post-ROD)	Continue assessing IRC sites and refurbishing new SWH sites, adding at least 66,000 ac-d/yr of suitable habitat. Determine required rate of Level 3 implementation based on stages 1 and 2.
	Stage 4: Level 4 implementation (years 11–15 post-ROD)	Continue assessing IRC sites and refurbishing SWH sites, adding at least 66,000 ac-d/yr of suitable habitat. Continue to determine required rate of Level 4 implementation based upon previous stages.

Note: ac-d/yr = acre-days per year

Channel reconfigurations to create functional IRC habitat that would be implemented under this action include the following actions, either independently or in combination: modification of existing structures, placement of new structures, manipulation of existing off-channel habitats (chutes), and Mainstem channel widening. Existing SWH projects may also address the functional components of IRC habitat, therefore, adjustments to existing SWH can provide additional IRC habitat. The initial implementation would focus on development of IRCs through structure modifications on the insides of bends because that would tend to minimize potential adverse impacts from erosion and shoaling and because it is thought that interception and foraging improvements might be most readily accomplished in these areas.

Performance of IRC projects could be negatively affected by human activities such as commercial dredging or the construction of ports, docks, or other structures that disturb the river bed. Any of a number of these human activities could affect the river channel geomorphology or hydrodynamic conditions if they occur in close proximity to the IRC project area; thereby resulting in unknown changes to interception rates anticipated by project construction. However, based on hydraulic modeling, professional judgment, known sturgeon reproductive cycles, and historic field data collected at active dredge locations, such activities would not likely affect IRCs if:

- Activities are performed at least 200 feet away from existing or constructed rock structures.
- Activities occur along the outside of the bend.
- Activities do not interfere with the interception source/sturgeon reproductive cycles, (i.e., occurring from September to March).

As part of the IRC projects, USACE proposes protective measures within the proposed project area to reduce the potential for human influences to impact geomorphology and hydrodynamic conditions, thereby negatively affecting or influencing the anticipated interception rate(s) and habitat outputs. A 200-foot buffer would be implemented at each IRC project and control bend to minimize potential effects from human activities that disturb the river bed. A portion of the buffer would be seasonal and would protect the larval pallid sturgeon interception source during April through August; a time when sturgeon are likely to be actively spawning. Furthermore, the buffer would protect the geomorphology of the river associated to the IRC project.

For the purpose of evaluating potential impacts to the human environment from IRC habitat development, it was assumed that approximately 260 acres per year of IRC habitat would be realistically constructed through channel widening. It was also assumed that construction would occur in 13 years of the 15-year implementation timeframe considered for this planning process. Therefore, the HEC-RAS models, used as the basis for impact assessment, reflect about 3,380 acres (260 acres x 13 years) of accommodation space for new IRC habitat under Alternatives 3–6 (Table 2-23). Additional IRC habitat would be created by modifying structures to develop hydraulics to intercept free embryos into existing in-channel areas that contain the appropriate parameters of food and foraging habitat.

Table 2-23. Summary of Projected IRC Habitat Under Alternatives 3–6

River Reach	River Mile Start	River Mile End	Miles in Reach	Target Acres of IRC Habitat*
Ponca to Sioux City	753	735	18	0
Sioux City to Platte River	735	595	140	276
Platte River to Rulo	595	498	97	585
Rulo to Kansas River	498	367	131	670
Kansas River to Osage River	367	130	237	1,389
Osage River to Mouth	130	0	130	460
			Total	**3,380**

* All acreage achieved through channel widening. Acreage amounts assume a top width of 250 feet for projects between Ponca and Rulo and 300 feet for projects downstream of Rulo.

A conceptual channel widening of 250 feet was assumed for projects between Ponca and Rulo and 300 feet for projects downstream of Rulo for the required length of channel to simulate 3380 acres in the HEC-RAS models. The HEC-RAS models are not capable of simulating modifications to structures and existing SWH sites, however it is not anticipated that these measures would have any substantive effect to water surface elevations beyond the immediate modification area. When specific modification sites are identified, site-specific modeling and assessment would occur during detailed project design to ensure no substantive effects are realized. Land acquisition to implement the requirements described is summarized in Table 2-24.

Table 2-24. Land Acquisition Requirements to Implement Channel Widening Under

River Reach	Target Acres of SWH	Additional Land Required: Habitat Only (acres)[a]	Additional Land Required: Total (acres)[b]
Ponca to Sioux City	0	0	0
Sioux City to Platte River	276	0	0
Platte River to Rulo	585	0	0
Rulo to Kansas River	670	216	1,664
Kansas River to Osage River	1,389	14	108
Osage River to Mouth	460	0	0
Total	**3,380**	**230**	**1,772**

a Additional land requirements was determined by assessing if there were existing public lands (i.e., USACE, USFWS, or state conservation lands) within each river reach that may be appropriate for habitat development. If this value is zero it means that either there were no habitat targets within this reach for the alternative or the assessment determined that there was potential to achieve the habitat targets on existing public lands. These areas do not necessarily represent actual locations of future habitat development.

b For estimating purposes, it was assumed that 7.7 acres of land acquisition are required for every 1 acre of habitat needed. This is based on historic implementation data and accounts for factors such as parcel size and other real estate acquisition considerations.

2.8.5 Alternative 4 – Spring ESH Creating Release

Alternative 4 includes those common actions identified in Section 2.8.1 including mechanical ESH construction at anticipated levels shown in Table 2-13. Alternative 4 also includes adaptive management, Level 1 and 2 studies except for the one-time spawning cue release, spawning habitat construction, and early life stage pallid sturgeon habitat construction as specified under Alternative 3. The rest of this section describes the management action unique to Alternative 4, a spring habitat-creating flow release.

Alternative 4 reservoir operations would include a high spring release designed to create ESH for the least tern and piping plover. The spring plenary pulse and reservoir unbalancing including in the Master Manual would not be implemented. The following description of the spring-habitat creating flow release indicates how this action was modeled; however, actual implementation would be adjusted to respond to hydrologic conditions at the time. In any year, the implementation of this habitat-creating flow release would occur if System storage is at 42 MAF or greater on April 1, natural flows creating 250 acres of ESH have not occurred in the previous 4 years, and downstream flow limits are not exceeded (Table 2-25). If those conditions are met, the habitat-creating flow release would be implemented on April 1 with a release of up to 60 kcfs out of Gavins Point Dam, and as often as every 4 years. To achieve the Gavins Point Dam release, Fort Randall Dam releases would be increased a similar amount as Gavins Point and releases from Garrison Dam would be approximately 17.5 kcfs less than the Gavins Point release.

The duration of the release would increase as release magnitude is decreased. Table 2-26 shows the duration (number of days) required for the habitat-creating flow release at various discharges.

Table 2-25. Downstream Flow Limits During Habitat-Creating Release

Location	Thousand Cubic Feet Per Second (kcfs)
Omaha	71
Nebraska City	82
Kansas City	126

Table 2-26. Estimated Durations of Habitat-Creating Flow Release

Gavins Point Release (kcfs)	Required Number of Days
60.0	35
55.0	49
50.0	77
45.0	175

If downstream flow limits are exceeded, the Gavins Point release would be reduced by 5 kcfs until the flow limits are no longer exceeded. In instances where the Gavins Point release falls below 45 kcfs, the release would be terminated. Modeling indicates that over the POR, the spring habitat-creating flow release as defined here would have been implemented 9 times and would have been partially implemented 6 times. Partial implementation means that the criteria were met in that year to initiate the flow release but it was terminated before completion.

Under current operations, navigation releases are computed based on the current service level prior to flood targets being assessed. Flow support for navigation and other downstream purposes is defined based on service level. A “full-service” level of 35.0 kcfs results in target flows of 31.0 kcfs at Sioux City and Omaha, 37.0 kcfs at Nebraska City, and 41.0 kcfs at Kansas City. Similarly, a “minimum-service” level of 29.0 kcfs results in target flow values of 6.0 kcfs less than the full-service levels. If System storage is high enough to warrant evacuation of flood storage, the service level will be greater than 35.0 kcfs.

The following example assumes a service level of 40.0 kcfs is the operations target. Navigation discharges for each of the target locations are computed based on Table 2-27 (Table VII-1 in the Master Manual (USACE 2006a)). These navigation discharges are the required discharges at the four target locations to support navigation. For a 40.0 kcfs service level, the required navigation discharges at Sioux City, Omaha, Nebraska City, and Kansas City are 36.0 kcfs (40.0 − 4.0); 36.0 kcfs (40.0 − 4.0); 42.0 kcfs (40.0 + 2.0); and 46.0 kcfs (40.0 + 6.0), respectively.

Table 2-27. Relation of Target Discharges to Service Level

Navigation Target Location	Navigation Target Flow Deviation from Service Level
Sioux City	-4.0 kcfs
Omaha	-4.0 kcfs
Nebraska City	+2.0 kcfs
Kansas City	+6.0 kcfs

Source: USACE 2006a, Table VII-1

Once navigation discharges are calculated, two tiers of flood target discharges are calculated and forecasted discharges are checked against the flood discharges. The first tier reduces navigation target flows to those consistent with full-service level of 35.0 kcfs when one or more of the forecasted downstream flows exceed the values in Table 2-28 (Table VII-7 in the Master Manual (USACE 2006a)). The second tier reduces navigation target flows to those consistent with minimum-service level of 29.0 kcfs when one or more of the forecasted downstream flows exceed the values in Table 2-29 (Table VII-8 in the Master Manual (USACE 2006a)).

Table 2-28. Full-Service Flood Target Flows

Flood Target Location	Flood Target Flow
Omaha	(navigation target flow + 10.0 kcfs)
Nebraska City	(navigation target flow + 10.0 kcfs)
Kansas City	(navigation target flow + 30.0 kcfs)

Source: USACE 2006a, Table VII-7

Table 2-29. Minimum-Service Flood Target Flows

Flood Target Location	Flood Target Flow
Omaha	(navigation target flow + 15.0 kcfs)
Nebraska City	(navigation target flow + 20.0 kcfs)
Kansas City	(navigation target flow + 60.0 kcfs)

Source: USACE 2006a, Table VII-8

Using Table 2-28 for a 40.0 kcfs service level, full-service flood target discharges at Omaha, Nebraska City, and Kansas City are 46.0 cfs (36.0 + 10.0); 52.0 kcfs (42.0 + 10.0); and 76.0 kcfs (46.0 + 30.0), respectively. If discharges at Omaha, Nebraska City, or Kansas City are forecasted to exceed their full-service flood targets, Gavins Point releases are then decreased until the full-service flood targets of 46.0 kcfs, 52.0 kcfs, and 76.0 kcfs are no longer forecasted to be exceeded while still maintaining at least full-service discharges at each of the target locations.

Using Table 2-29 for a 40.0 kcfs service level, minimum-service flood target discharges at Omaha, Nebraska City, and Kansas City are 51.0 kcfs (36.0 + 15.0); 62.0 kcfs (42.0 + 20.0); and 106.0 kcfs (46.0 + 60.0), respectively. If discharges at Omaha, Nebraska City, or Kansas

City are forecasted to exceed their minimum-service flood targets, Gavins Point releases are then decreased until the minimum-service flood targets of 51.0 kcfs, 62.0 kcfs, and 106.0 kcfs are no longer forecasted to be exceeded while still maintaining at least minimum-service discharges at each of the target locations. These calculations are summarized in Table 2-30.

The habitat-creating flow release of 60 kcfs from Gavins Point could not occur under current operations because of how the flood target criteria are operationally applied. If 60.0 kcfs were released from Gavins Point and it was assumed that all tributaries between Gavins Point and Omaha were dry, there would still be 60.0 kcfs at Omaha due to releases from Gavins Point. A 60.0 kcfs discharge at Omaha exceeds both the full-service flood target of 46.0 kcfs and the minimum-service flood target of 51.0 kcfs for a 40.0 service level. If the current flood target operations were used, the habitat-creating flow release would never have a chance to occur until the service level exceeded 49.0 kcfs; therefore, in order to allow this high release from Gavins Point, it was necessary to modify how the flood target criteria is applied during times when a habitat-creating flow release is attempted. This revision results in the downstream flow limits presented in Table 2-25.

Table 2-30. Example Navigation and Flood Target Discharges for a 40.0 kcfs Service Level Under Current Operations

Location	Navigation Discharge for 35.0 Service Level (Full-Service) (kcfs)	Navigation Discharge for 29.0 Service Level (Minimum-service) (kcfs)	Navigation Discharge for Example 40.0 Service Level (kcfs)	Full-Service Flood Target (kcfs)	Minimum-Service Flood Target (kcfs)
Sioux City	31.0	25.0	36.0	-	-
Omaha	31.0	25.0	36.0	46.0	51.0
Nebraska City	37.0	31.0	42.0	52.0	62.0
Kansas City	41.0	35.0	46.0	76.0	106.0

2.8.6 Alternative 5 – Fall ESH Creating Release

Alternative 5 includes those common actions identified in Section 2.8.1 including mechanical ESH construction at anticipated levels shown in Table 2-13. Alternative 5 also includes adaptive management, Level 1 and 2 studies except for the one-time spawning cue release, spawning habitat construction, and early life stage pallid sturgeon habitat construction as specified under Alternative 3. The rest of this section describes the management action unique to Alternative 5, a fall habitat-creating flow release.

Alternative 5 reservoir operations would include a high fall release designed to create ESH for the least tern and piping plover. The spring plenary pulse and reservoir unbalancing included in the Master Manual would not be implemented. The following description of the fall-habitat creating flow release indicates how this action was modeled; however, actual implementation would be adjusted to respond to hydrologic conditions at the time. In any year, the implementation of this habitat-creating flow release would occur if System storage is 54.5 MAF or greater, natural flows creating 250 acres of ESH have not occurred in the previous 4 years, and downstream flow limits are not exceeded. Downstream flow limits for Alternative 5 would be the same as that for Alternative 4 (Table 2-25). If those conditions are met, the habitat-creating flow release would be implemented on October 17 with a release of up to 60 kcfs out of Gavins

Point Dam, and as often as every 4 years. To achieve the Gavins Point Dam release, Fort Randall Dam releases would be increased a similar amount as Gavins Point and releases from Garrison Dam would be approximately 17.5 kcfs less than the Gavins Point release. As with Alternative 4, the duration of the release would increase as release magnitude is decreased (Table 2-26).

If downstream flow limits are exceeded, the Gavins Point release would be reduced by 5 kcfs until flood targets are no longer exceeded. In instances where the Gavins Point release falls below 45 kcfs, the release would be terminated. Modeling indicates that over the POR, the fall habitat-creating flow release as defined here would have been implemented 7 times and would have been partially implemented once.

2.8.7 Alternative 6 – Pallid Sturgeon Spawning Cue

Alternative 6 includes those common actions identified in Section 2.8.1 including mechanical ESH construction at anticipated levels shown in Table 2-13. The spring plenary pulse and reservoir unbalancing included in the Master Manual would not be implemented. Alternative 6 also includes adaptive management, spawning habitat construction, and early life stage pallid sturgeon habitat construction as specified under Alternative 3. Alternative 6 includes Level 1 and 2 studies as described under Alternative 3, except for the one-time spawning cue release. This test release is not applicable to Alternative 6, because the management action unique to Alternative 6 is a recurring pallid sturgeon spawning cue release. The rest of this section describes that spawning cue release. The following description of the spawning cue release indicates how this action was modeled; however, actual implementation would be adjusted to respond to hydrologic conditions at the time.

Under Alternative 6, USACE would attempt a spawning cue release every 3 years consisting of a bimodal pulse in March and May. These spawning cue releases would not be started or would be terminated whenever downstream flow limits are exceeded. HEC-ResSim modeling indicates that over the POR, the spawning cue release as defined here would have been implemented 6 times and would have been partially implemented 21 times.

March Pulse: USACE would initiate a March pulse once navigation releases were met at downstream target locations. A minimum of 40.0 MAF in System storage is required on March 15 for the March pulse to occur. If System storage is at least 40.0 MAF on March 15, the spawning cue would begin once navigation target flows are reached at each of the four target locations. The peak Gavins Point release would be two times the navigation release on the pulse initiation day. Flows would increase 2,200 cfs per day until the pulse peak is achieved, held for two days, and then reduced daily by 1,700 cfs per day until flow-to-target navigation releases are reached. Table 2-31 provides downstream flow limits associated with a March pulse. Based on HEC-ResSim POR simulations, Gavins Point releases during the March spawning cue would be 39–61 kcfs.

Table 2-31. Alternative 6 March Pulse Downstream Flow Limits

Location	Thousand Cubic Feet Per Second (kcfs)
Omaha	41 + Pulse Magnitude
Nebraska City	47 + Pulse Magnitude
Kansas City	71 + Pulse Magnitude

May Pulse: USACE would initiate a second pulse annually during May when water temperatures reach 16–18 °C (for modeling purposes, May 18 was the target date). The peak Gavins Point release would be two times the base release on the pulse initiation day. Flows would increase 2,200 cfs per day until the pulse peak is achieved, held for two days, and then reduced daily by 1,900 cfs per day until base flow is reached. Table 2-32 provides downstream flow limits associated with a May pulse. Based on HEC-ResSim POR simulations, Gavins Point releases during the May spawning cue would range from 50–67 kcfs.

Table 2-32. Alternative 6 May Pulse Downstream Flow Limits

Location	Thousand Cubic Feet Per Second (kcfs)
Omaha	41 + Pulse Magnitude
Nebraska City	47 + Pulse Magnitude
Kansas City	71 + Pulse Magnitude

2.9 Comparison of Alternatives

The potential impacts associated with each of the alternatives have been assessed and the findings are discussed in detail in Chapter 3 and further described in a series of technical reports available at www.moriverrecovery.org.

This section provides an overview of the results of the impacts analysis. Table 2-33 summarizes the consequences of the alternatives on objectives and performance measures. This section then summarizes the differences between alternatives; discusses how the alternatives are different hydrologically; discusses some of the implications of these differences for endangered species and HC in terms of relative benefits and adverse impacts compared with Alternative 1; and provides a brief summary of the USACE evaluation using the four criteria specified in the Principles and Guidelines (Acceptability, Completeness, Effectiveness, Efficiency). The criteria are defined in the Principles and Guidelines as follows:

- Acceptability is the workability and viability of the alternative plan with respect to acceptance by state and local entities and the public and compatibility with existing laws, regulations, and public policies.
- Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.
- Effectiveness is the extent to which an alternative alleviates the specific problems and achieves the specified opportunities (e.g., the purpose, need, and objectives).
- Efficiency is the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment.

Collectively, these evaluations provide the rationale for the identification of a preferred alternative for the MRRMP-EIS, which is further described in Section 2.10.

2.9.1 Average Annual Consequences Summary Table

Table 2-33 summarizes the average annual consequences of implementing each of the alternatives.

Although absolute values provide important context, it is more relevant for decision-makers to consider the estimated differences between each of the action alternatives and Alternative 1. Table 2-33 shows the differences in the performance of Alternatives 2 through 6 in relation to Alternative 1.

Average annual numbers provide an important but incomplete perspective on the impacts of the alternatives. In some cases, they can give a misleading impression of the relative impacts. For example, for any given resource area, 20 individual years may have a small negative impact, and 1 year may have a very large positive impact relative to Alternative 1. In an average annual calculation, this might amount to crediting an alternative with a positive impact, which may be misleading. For this reason, it is important to understand the year-by-year impacts of each alternative, discussed in detail in Chapter 3 and further described in a series of technical reports available at www.moriverrecovery.org. In this summary discussion, only the most sensitive of cases of this effect are noted.

Table 2-33. Environmental Consequences of the Action Alternatives Compared to No Action (Alternative 1)

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
River Infrastructure and Hydrologic Processes							
Other	Impacts to hydrology	Spawning cue releases would be small and result in negligible impacts Negligible to small adverse impacts from mechanical ESH construction (upper river) and channel reconfiguration projects (lower river)	Temporary and long-term, small adverse impacts from spawning cue releases; impacts could be large locally Small to large adverse impacts from mechanical ESH construction (upper river) Negligible to small impacts from SWH construction because of localized nature of impacts	No to negligible adverse impacts to hydrology because of the absence of a reoccurring spawning cue and inclusion of spawning cue test release Negligible to small adverse impacts from mechanical ESH construction (upper river) and IRC construction (lower river)	Temporary and long-term, small adverse impacts from spring ESH creation releases Negligible to small adverse impacts from mechanical ESH construction (upper river) and IRC construction (lower river)	Same as Alternative 4, except timing of impacts (fall) from ESH creation releases	Same as Alternative 4, though slightly smaller impacts from spring spawning cue release
Other	Impacts to geomorphology	Existing geomorphological processes and trends would continue	Temporary and long-term, small adverse impacts from spawning cue releases; impacts could be large locally	Temporary, small, adverse impacts from one-time spawning cue test release	Temporary and long-term, small adverse impacts from spring ESH creation release; impacts could be large locally	Same as Alternative 4, except timing of impacts (fall) from ESH creation releases	Same as Alternative 4, though slightly smaller impacts from spring spawning cue release
Other	Impacts to river infrastructure	Changing flows would affect river infrastructure	Long-term, small adverse impacts given the variability in flows and processes	Temporary or long-term, no to negligible adverse impacts as no impact to flow rate or stage	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2
Other	Impacts to groundwater elevation	Changing flows would affect river groundwater levels	Temporary, small adverse impacts from flow releases	No impacts	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Pallid Sturgeon							
EQ	Impacts to pallid sturgeon population	Negligible impacts from habitat construction Possible long-term benefits from SWH construction, although benefits to age-0 sturgeon are uncertain	Temporary, negligible adverse impact from habitat construction Potential benefits from SWH creation, spawning cue release, floodplain connectivity and adaptive management	Temporary, negligible adverse impact from habitat construction Potential long-term benefits from spawning sites, IRC creation, and adaptive management	Same as Alternative 3 Negligible impacts from spring ESH creating releases	Same as Alternative 3 No impacts from fall ESH creating releases	Same as Alternative 3 Potential benefits from spawning cue releases
Piping Plover and Least Tern (numbers reported in absolute values)							
EQ	Likelihood of meeting piping plover sub-objective 1 (geographic distribution)	Assumed to be met if sub-objectives 2, 3, and 4 are met in both regions (north and south)					
EQ	Piping plover sub-objective 2: north (extinction probability) -lower is better	5.7%	1.4%	4.9%	5.0%	4.9%	4.9%
EQ	Piping plover sub-objective 2: south (extinction probability) - lower is better	26.7%	0.68%	5.0%	5.0%	5.1%	5.0%

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
EQ	Piping plover sub-objective 3 (percent of simulated years where median λ ≥ 1) - higher is better	51%	96%	84%	47%	74%	47%
EQ	Piping plover sub-objective 4 (percent of simulated years where median fledge ratio ≥1.14) - higher is better	22%	98%	98%	60%	84%	33%
Fish and Wildlife							
EQ	Habitat quality and availability	Temporary, negligible to small adverse impacts from habitat construction during construction Long-term, large benefits	Temporary, negligible to large adverse impacts from habitat construction Overall change in habitat type would be small Localized, large, adverse impact to reservoir fisheries if reservoir criteria not met as a result of low summer flows and/or spring spawning cue release Long-term, large benefits	Temporary, negligible to small adverse impacts from habitat construction Localized, large, adverse impact to reservoir fisheries if reservoir criteria not met during the potential one-time spring pulse flow test Long-term, negligible to small benefits	Localized, large, adverse impact to reservoir fisheries if reservoir criteria not met as a result of spring ESH creation release Other impacts Same as Alternative 3	Localized, large, adverse impact to reservoir fisheries if reservoir criteria not met as a result of fall ESH creation release Other impacts Same as Alternative 3	Localized, large, adverse impact to reservoir fisheries if reservoir criteria not met as a result of spring spawning cue release Other impacts Same as Alternative 3

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Other Special Status Species – Bald Eagle, Northern Long-Eared Bat, Indiana Bat							
EQ	Habitat quality and availability	Temporary, negligible, adverse impacts from construction activities Long-term benefits from 7,046 acres acquired	Temporary, negligible, adverse impacts from habitat construction Long-term, benefits from 45,716 acres acquired	Temporary, negligible, adverse impacts from habitat construction Long-term benefits from 1,772 acres acquired)	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Water Quality							
EQ	Water quality parameters (e.g., temperature, dissolved oxygen, and nitrogen and phosphorus)	Temporary, negligible, adverse impacts from increased nutrients, pollutants, and water temperature and lower dissolved oxygen levels Temporary, small adverse impacts from increased sediment and turbidity Long-term, negligible, beneficial impacts from reduced nutrients and pollutants	Temporary impacts would be the same as Alternative 1 Long-term, negligible adverse impacts could result from localized areas of increased water temperatures and less dissolved oxygen and negligible to small, beneficial impacts from reduced nutrients and pollutants	Temporary impacts would be the same as Alternative 1 Long-term impacts would be the same as Alternative 2	Temporary, impacts include negligible adverse impacts from increased nutrients, pollutants, and water temperature, and dissolved oxygen alterations, and small, adverse impacts from increased sediment and turbidity Long term negligible, beneficial impacts from reduced nutrients and pollutants	Temporary impacts include negligible adverse impacts from increased nutrients and pollutants, negligible to small adverse impacts from water temperature and dissolved oxygen alterations, and small, adverse impacts from increased sediment and turbidity Long term negligible, beneficial impacts from reduced nutrients and pollutants	Temporary impacts would be the same as Alternative 5 Long-term impacts would be the same as Alternative 5

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Air Quality							
EQ	Air quality parameters (i.e., criteria air pollutants and greenhouse gas emissions)	Localized, temporary, negligible, adverse impacts from habitat construction-related emissions	Localized, temporary negligible adverse impacts would be similar to Alternative 1, but slightly worse as more habitat would be constructed	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Cultural Resources (numbers reported are relative to Alternative 1)							
EQ	Max. No. of Sites Affected (reservoir sites)	1,138	-22	0	+1	0	+1
EQ	Max. No. of Sites Affected (riverine sites)	1,483	-8	0	0	0	-1
EQ	Ave Annual Sites-days (reservoir sites)	55,937	+1,614	-237	+1,707	+879	+2,464
EQ	Ave Annual Sites-days (riverine sites)	16,430	-50	-16	+38	-68	+53
Land Ownership (numbers reported are relative to Alternative 1)							
RED	Regional employment (jobs) -higher is better	-23 jobs	-117 jobs	+16 jobs	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
RED	Regional income -higher is better	-$1,100,000	-$6,200,000	+$843,000	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
RED	Tax revenues -higher is better	-$117,000	-$786,000	+$106,000	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
OSE	Relative impacts to individual and community resiliency, traditional ways of life, and economic vitality	Negligible to small adverse impacts to individual and community resiliency, traditional ways of life, and economic vitality	Negligible to large, adverse impacts depending on the concentration of acquired lands	Negligible adverse impacts	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Commercial Sand / Gravel Dredging							
Other	Changes measured in average annual sedimentation accumulation rate	Negligible measured change in the average annual sediment accumulation rate	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Other	Potential protective measures	Small adverse impacts from SWH construction and potential protective measures	Same as Alternative 1	Small adverse impacts from IRC protective measures	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Flood Risk Management (numbers reported are relative to Alternative 1)							
NED	Ave. $NED/yr damages -lower is better	$30,482,337	-$1,705,203	-$232,725	-$688,044	-$548,536	+$282,851
RED	Ave. regional employment (jobs) -higher is better	Range in reduction in job losses (1–40)	+4	0	+1	+1	-1
RED	Ave. $RED/yr income -higher is better	-$46,000 to -$2,600,000	+$188,000	-$8,000	+$73,000	-$4,000	-$65,000

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
OSE	Population at risk (individuals) -lower is better	592	-26	-4	-5	-14	-5
OSE	Sum of Ft. Randall and Garrison reaches exceedances in POR (days) -lower is better	53	+427	-53	+793	+495	+541
Other	Impacts from habitat construction	Small benefits limited to downstream areas from habitat construction	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Interior Drainage (numbers reported in absolute values)							
NED	Ave. $NED/yr damages at individual sites	$120,000 to $399,000	$114,000 to $387,000	$123,000 to $399,000	$123,000 to $399,000	$124,000 to $398,000	$124,000 to $397,000
RED	Ave. regional employment (qualitative)	Negligible to small adverse impacts	Negligible impact	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2
OSE	Population at risk (qualitative)	No impacts	No impacts	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2
Other	Impacts from habitat construction	No to negligible impacts from habitat construction actions	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Hydropower (numbers reported are relative to Alternative 1)							
NED	Ave. $NED/yr -higher is better	$491,099,000	-$3,099,000	+$203,000	-$3,771,000	-$1,031,000	-$3,209,000

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
RED	Increased Cost to WAPA (Ave. $/yr) -lower is better	+$1,761,000	+$30,000	-$102,000	+$1,156,000	+$356,073	+$792,000
OSE	Ave. change to CO2 (lb/yr) -lower is better	15,889,805,078	+9,855,094	-10,999,306	+109,769,010	+35,854,585	+76,021,175
Irrigation (numbers reported are relative to Alternative 1)							
NED	Ave. $/yr net farm income -higher is better	$6,800,000	-$83,000	+$15,000	-$69,000	+$44,000	-$115,000
RED	Ave. regional employment (jobs) -higher is better	341	Decrease <1	Increase <1	Decrease <1	Increase <1	Decrease <1
RED	Ave. labor income yr income ($) -higher is better	$13,600,000	-$28,000	+$4,000	-$14,000	+$21,000	-$30,000
OSE	Relative impacts to community well-being, traditional ways of life, and economic vitality	Negligible long-term impacts to community well-being, traditional ways of life, and economic vitality.	Short-term small adverse and long-term negligible impacts to community well-being, traditional ways of life, and economic vitality.	Same as Alternative 2	Same as Alternative 2	Same as Alternative 1	Same as Alternative 2

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Other	Impacts from habitat construction	Temporary, localized, relatively small adverse impacts limited to intakes near habitat construction	Temporary, localized, relatively small adverse impacts limited to intakes near habitat construction, though greater than Alternative 1 given the amount of habitat constructed	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Navigation (numbers reported are relative to Alternative 1)							
NED	Ave. $NED/yr	$7,400,000	-$35,000	+$21,000	-$181,000	-$57,000	-$127,000
RED	Ave. regional employment (jobs) -higher is better	154	0	0	-2	0	-1
RED	Ave. $RED/yr income -higher is better	$8,800,000	-$11,000	+$13,000	-$94,000	-$9,000	-$85,000
OSE	Relative impacts to air quality	Negligible impacts to air quality, traffic congestion, public health and safety, and infrastructure costs in the regional context	Negligible change in air quality, traffic congestion, public health and safety, and infrastructure costs because of the small change air emissions and truck transportation in the region	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Recreation (numbers reported are relative to Alternative 1)							
NED	Ave. $/yr recreation value -higher is better	$102,400,000	+$112,000	+$83,000	-$1,100,000	-$86,000	-$846,000
RED	Ave. employment (jobs) (Mainstem reservoirs) -higher is better	1,512	-3	2	-21	-1	-18
RED	Ave. $RED income (Mainstem reservoirs) -higher is better	$42,400,000	-$108,000	+$70,000	-$585,000	-$29,000	-$511,000
OSE	Relative impacts to individual and community well-being and quality of life	Large benefits associated with considerable recreational opportunities	Relatively higher OSE benefits to recreation	Negligible Changes in OSE Benefits from Alternative 1	Negligible Changes in OSE Benefits from Alternative 1	Negligible Changes in OSE Benefits from Alternative 1	Negligible Changes in OSE Benefits from Alternative 1
Other	Impacts from habitat construction	Temporary, small, adverse impacts from habitat construction Relatively long-term, small benefits	Temporary, small to large adverse impacts from habitat construction Relatively long-term, small to large benefits	Similar to Alternative 1	Similar to Alternative 1	Similar to Alternative 1	Similar to Alternative 1
Thermal Power (numbers reported are relative to Alternative 1)							
NED	Ave. $/yr energy values + capacity value-variable cost. -higher is better	$3,645,386,757	-$59,994,334	+$16,813	-$3,124,916	-$1,006,844	-$1,245,525

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
RED	Variation in power generation (qualitative)	Variations in power generation would range considerably with a worst-case decrease of ~6 million MWh during drought conditions from normal conditions. Alternative 1 management actions (spring pulse) would have a negligible impact	Relatively higher wholesale energy prices, especially during low summer flow events, with the potential for an increase in retail electricity rates over time compared to Alternative 1. Relatively long-term and adverse impacts to spending and regional economic conditions could occur	Negligible change from Alternative 1	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
OSE	Ave. change to CO^2 (lb/yr) -lower is better	167,000,000,000	+15,400,000	-5,800,000	-113,800,000	-18,900,000	-33,900,000
Other	Impacts from habitat construction	Temporary, negligible to small, adverse impacts	Temporary, small to large adverse impacts	Negligible impact	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Water Supply (numbers reported are relative to Alternative 1)							
NED	Ave. $NED/yr -lower is better	$584,000	-$6,000	-$3,600	+$28,000	+$1,200	+$24,800
RED	Change in water utility rates (qualitative)	Intake improvements may result in increases in water rates to customers	Negligible impact	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2
OSE	Change in water supply access (qualitative)	Negligible impact	Short-term small benefits	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Other	Impacts from habitat construction	Temporary, localized, small, adverse impacts to water supply intakes located in reaches where the habitat construction would take place	Temporary, potential for small, adverse impacts from large amount of habitat construction to water supply intakes located in reaches where the habitat construction would take place	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Wastewater							
Other	Pollutant effluent limits	Negligible impacts allowing facilities to continue to operate within existing parameters	Negligible impacts to waste water facilities in most locations. Possible short-term, large, adverse impacts to two wastewater facilities are anticipated, although future investments in treatment technology could reduce impacts to small	Negligible to small adverse impacts	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Tribal Interests							
OSE	Ability of Tribal members to use the floodplain in terms of subsistence hunting, fishing and gathering, traditional cultural practices and educational opportunities	Habitat improvements would continue to provide long term opportunities for subsistence hunting, fishing, and gathering and for traditional practices and educational opportunities.	Overall long-term benefits to subsistence hunting, fishing, and gathering and for traditional practices and educational opportunities from increased habitat improvements compared to Alternative 1.	Small decrease in opportunities for traditional cultural practices; benefits to subsistence gathering. Overall adverse impacts would be small Habitat improvements would continue to provide long term opportunities for subsistence hunting, fishing, and gathering and for traditional practices and educational opportunities, but to a lesser extent than Alternative 1.	Opportunities for traditional cultural practices and education in the upper river would be increased, while similar to Alternative 1 in the lower river. Benefits in the upper river provided to subsistence gathering; other impacts would be similar to Alternative 1	Same as Alternative 3	Small increase in opportunities for traditional cultural practices in the upper river and a decrease in the lower river; benefits to subsistence gathering would occur in the lower river, with decrease in the upper river. Overall adverse impacts would be small. Benefits from continued habitat improvements similar to Alternative 3.
Human Health and Safety							
OSE	Risk of mosquito-borne illness	No potential to create habitat for common vector mosquito species, therefore no adverse impacts on human health and safety	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Environmental Justice							
OSE	Disproportionate impact to EJ populations	Not expected to have disproportionate adverse impacts	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Ecosystem Services							
Ecosystem Services – Natural Resource Goods							
EQ	Change in availability in natural resource goods	Long-term, beneficial impacts to some types of wildlife and aquatic habitats, increasing the prevalence of fish and wildlife for subsistence, recreation, and potentially commercial harvesting. The provision of sediment would continue as a long-term benefit.	Higher long-term benefits to some fish and wildlife. No to negligible changes to commercial fishing. Negligible changes to the provision of sediment.	Negligible impact	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Ecosystem Services – Water Supply							
EQ	Impacts to surface and ground water	No impact	Long-term, negligible to small benefits	Negligible impact	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Ecosystem Services – Water Quality, Waste, Assimilation, Nutrient Regulation							
EQ	Changes in water quality, waste, assimilation, nutrient regulation	Long-term benefits from reduced sediment and turbidity, nutrients, and pollutants Negligible impact to waste assimilation	Long-term, negligible to small benefits on water quality, waste assimilation, and nutrient regulation	Negligible impact	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Ecosystem Services – Water Regulation and Flood Attenuation							
EQ	Change in water regulation and flood attenuation	The creation habitat would result in beneficial impacts to water regulation and flood attenuation through added conveyance that may slightly decrease river stage locally	Higher long-term benefits; may slightly decrease river stage locally	Negligible impact	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Ecosystem Services – Carbon Sequestration and Climate Regulation							
EQ	Level of carbon sequestration	Beneficial impact on carbon sequestration capacities from natural habitat creation and restoration	Relatively higher long-term benefits to carbon sequestration capacities compared to Alternative 1; long-term, negligible benefits to climate regulation	Negligible impact	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Ecosystem Services – Recreation							
EQ	Change in recreation value	Long –term benefits from habitat construction	Long-term, negligible to small benefits	Negligible impact	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Ecosystem Services – Land Values							
EQ	Change in property value	Properties near habitat areas could realize an increase in land and property values resulting in long-term, beneficial impact	Long-term, negligible to small benefits	Negligible impact	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Ecosystem Services – Other Cultural Services							
EQ	Impacts to cultural services	Habitat construction would provide beneficial impacts to other cultural services on the river and its related terrestrial lands	Small benefits	Negligible impact	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Ecosystem Services – Non-Use Values							
EQ	Ability to meet species' objectives	Reduced likelihood of meeting the species objectives, with potential adverse impacts to non-use values	Higher long-term benefits from substantially more habitat creation	Higher long-term benefits, though not as much as Alternative 2	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Middle Mississippi River							
Middle Mississippi River – River Infrastructure and Hydrologic Processes (numbers reported are relative to Alternative 1)							
EQ	Impacts to flow or stage (feet)	Existing hydrologic conditions in the Middle Mississippi River would continue and the spawning cue release pulses would be mostly attenuated by the time they reach the Middle Mississippi River and would not cause impacts	Potential to result in -1 to -2 change in stage; short-term change in July and August	No impacts	Potential to result in +1 to +3 change in stage; long-term, negligible to small adverse impacts	Potential to result in +1 to +3 change in stage, long-term, negligible to small adverse impacts	Potential to result in +2 change in stage, long-term, negligible to small adverse impacts

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Middle Mississippi River – Biological Resources							
EQ	Impact to side channel habitat condition or accessibility (qualitative)	The periods of connection and disconnection of the side channels would be a result of natural cycles rather than caused by management actions	No impact	No impact	No impact	No change to a small benefit in connectivity and flow status	No change to a small benefit in connectivity and flow status
Middle Mississippi River – Flood Risk Management (numbers reported are relative to Alternative 1)							
NED	Ave. $NED/yr damages -lower is better	$13,894,000	-$11,898,000 to +$6,345,000	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2	Same as Alternative 2
OSE	Impacts to individual and community safety, health, and well-being (Ave. PAR/yr) -lower is better	196	-3	-1	-3	0	-1
Middle Mississippi River – Navigation (numbers reported are relative to Alternative 1)							
NED	Ave. $NED/yr (costs) -lower is better	$43,800,000	+$13,942	-$14,900	+$153,000	-$7,900	+$197,000

Summary of Environmental Consequences			Comparison to Alternative 1				
Account	**Metric**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Middle Mississippi River – Water Intakes							
Other	River stages below threshold (qualitative)	Temporary, negligible to small, adverse impacts from river stages falling below critical thresholds; however, management actions would not contribute to these adverse effects	Temporary, negligible to small adverse impacts from small increase in days below critical threshold	No to negligible adverse impacts	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
Program Expenditures (NED reported in absolute values; RED reported in numbers relative to Alternative 1)							
NED	Ave. Annual NED Implementation Costs -lower is better	$74,503,778	$196,956,768	$40,863,033	$36,915,915	$37,909,346	$37,856,127
RED	Long-term, Ave. regional employment (jobs) -higher is better	495	+666	-110	-164	-150	-151
RED	Long-term, Ave. $RED/yr income -higher is better	$28,000,000	+$33,800,000	-$5,900,000	-$8,600,000	-$7,900,000	-$8,000,000

2.9.2 Discussion of Consequences

2.9.2.1 Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)

Summary of Characteristics and Features

Alternative 1 is a continuation of the current operation of the System and also management actions being used to comply with the 2003 BiOp (USFWS 2003). Although referred to as "No Action" because it is the default reference case under NEPA, the No Action alternative could be referred to as no change in direction from existing operation and implementation of the MRRP. For pallid sturgeon, the range of actions includes a propagation program, shallow water habitat (SWH) construction and the spawning cue flow release included in the current Master Manual. For the listed bird species, the range of actions includes the mechanical construction of approximately 164 acres per year of ESH in years when construction occurs and the use of other management actions to increase survival.

For pallid sturgeon, although there are potentially long-term benefits from SWH construction, it is uncertain how SWH addresses hypotheses developed through the effects analysis. No beneficial impacts to the pallid sturgeon are thought to be attributable to the spawning cue release as defined by the technical criteria in the Master Manual and described under Alternative 1. Alternative 1 does not meet the species objective of providing a 95 percent chance of persistence for the piping plover over the 50-year modeled period. The AM approach under Alternative 1 would remain focused on evaluation of actions from the 2003 Biological Opinion such as ESH and SWH.

Evaluation Discussion

It appears that Alternative 1 is insufficient in meeting the piping plover population persistence targets and therefore is not a complete plan and would not be effective in meeting all of the species objectives. In addition, other alternatives that meet all of the species objectives would be less costly than Alternative 1. The acceptability of Alternative 1 would likely be varied based on Draft EIS comments and experience with implementation of past management actions included in Alternative 1. Some stakeholders are supportive of managed flow pulses, habitat construction, land acquisition, and other management actions for the listed species while some are opposed. Given that USACE must comply with the ESA to continue to operate the System and maintain and operate the BSNP, and an appropriate level of action is necessary, Alternative 1 would likely be workable and viable with adjustments as needed based on Tribal, stakeholder, and agency feedback during implementation. Although it is a selectable alternative, the primary purpose of Alternative 1 is to serve as a reference case to compare the relative benefits and adverse impacts of the action alternatives.

2.9.2.2 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Summary of Characteristics and Features

Alternative 2 represents USFWS's interpretation of the management actions that could ultimately be implemented as part of the 2003 BiOp RPA. Alternative 2 includes actions that USFWS anticipates would ultimately be implemented through AM and as impediments to implementation were removed.

The main features of this alternative for the listed bird species are an ESH mechanical construction rate of 1,331 acres per year and lowered nesting season flows (otherwise referred to as low summer flows). For pallid sturgeon, Alternative 2 calls for the continuation of the propagation and augmentation program; the construction of up 30 acres of SWH per river mile between Ponca, Nebraska and the confluence with the Mississippi River; an annual spring pallid sturgeon flow release comprising two pulses, one each in March and May, when these are possible within certain System condition constraints; and 77,000 acres of connected floodplain (i.e., periodically inundated land) with a long-term expected frequency of one year in five.

Over the POR, the main hydrological differences of Alternative 2 relative to Alternative 1 include

- Higher flows in approximately 50 percent of years during March and/or May as the spring pallid sturgeon flow releases are attempted (System conditions preclude noticeable higher flows in the remaining years);
- Lower summer flows in approximately 12 percent of years (the nesting flow operation is only invoked on the fully successful implementation of both pulses of the spring pallid sturgeon flow release); and
- Lower winter flows (from the second week in December to mid-March) in approximately 35 percent of years.

Balance of Beneficial and Adverse Effects

The net benefits of Alternative 2 compared to Alternative 1 mainly relate to listed species, improvements in net overall flood risk management performance and benefits to recreation from a NED perspective. There would also be benefits to fish and wildlife and ecosystem services through land acquisition and habitat restoration, and regional income and job creation provided by program expenditures associated with habitat construction.

There would be possible beneficial impacts to pallid sturgeon from the spring pallid sturgeon flow release and low summer flow operations, but evidence is lacking to confirm or quantify the level of benefit. Over the long term, it is uncertain how beneficial SWH would be to age-0 pallid sturgeon but parameters defining SWH are not as well linked to specific pallid sturgeon hypotheses resulting from the effects analysis as the IRC parameters. There also may be unquantified benefits to pallid sturgeon from floodplain connectivity. Limited beneficial impacts from AM focused on the aforementioned management actions would be anticipated. For the piping plover, modeling indicates that updated population persistence targets would be exceeded under Alternative 2.

Alternative 2 would have net benefits to flood risk management on an average basis, reducing flood risk management impacts by approximately $1.7 million per year. In 85 percent of years in the POR, there would be a net improvement in flood risk management outcomes relative to Alternative 1, including some large improvements in the lower river in the high flood risk years of 1993 and 2011. Modeled discharges from Gavins Point were identical for Alternatives 1 and 2 in 1993 and 2011; however, channel changes associated with early life stage pallid sturgeon habitat construction under Alternative 2 reduce the stage associated with these high flows by a number of inches. Flood risk modeling indicates this would avoid substantial flood damage (approximately 5 percent reduction in damages relative to Alternative 1 using 1993 flow data and 18 percent reduction in damages using 2011 data). The net flood benefits in these years would extend into the Mississippi River. However, in 15 percent of years in the POR, Alternative 2 would have large, negative impacts relative to Alternative 1 associated with full and partial spring pallid sturgeon flow releases which increase the risk of flooding. Despite net benefits in flood risk management there would be instances of adverse impacts in some areas associated with the March and May spring pulse release such as in areas with limited channel capacity like the Fort Randall Reach and Garrison Reach.

Alternative 2 would have regional benefits that follow from program expenditures associated with habitat construction. Relative to Alternative 1, Alternative 2 would support an annual average of 1,951 additional jobs in the first 15 years of the project and would result in $102.4 million in additional regional labor income annually during the project. Alternative 2 would result in an overall increase in recreation value due to habitat construction in the lower river but a decrease in recreation in the reservoirs due to, on average, lower summer reservoir levels. Alternative 2 may result in higher but unquantified benefits to ecosystem services.

The net adverse effects of Alternative 2 relative to Alternative 1 concern a broad range of human considerations (HC), including program costs, a higher amount of temporary construction related impacts, cultural resources, thermal power, navigation, hydropower, irrigation, and land ownership. Alternative 2 would require a large increase in federal funding for program expenditures, driven primarily by increased ESH and SWH construction and land acquisition requirements under this alternative. Alternative 2 would result in an increase in total cultural site days at risk in the reservoirs as compared to Alternative 1, and riverine reaches would have an increase in severity of impacts.

Modeling suggests that there would be an approximately $60 million decrease, or 1.6% decrease, in average annual thermal power NED benefits compared to Alternative 1. The low summer flow events as simulated under Alternative 2 would result in adverse impacts to power generation and energy and capacity replacement costs compared to Alternative 1. As simulated in 1988, the worst-impacted year compared to Alternative 1, there would be a 29.1 percent (5.2 million MWh) decline in power generation relative to average annual generation in the summer under Alternative 1. Alternative 2 would result in the largest adverse impact to capacity for the power plants in the lower river, a reduction in 396 MW of dependable capacity and an increase in $52.9 million in annual replacement capacity costs. These impacts could be significant, although there is uncertainty associated with these estimates for thermal power. These estimates are generated with input from industry as well as from regulatory requirements along with the USACE HEC-RAS and river water temperature modeling data.

The overall impact of Alternative 2 as compared to Alternative 1 would be a loss of approximately $3.1 million in hydropower generation and dependable capacity. This is a loss of 0.63 percent of the overall system value calculated under Alternative 1. However, large declines would occur in some years especially at Oahe, Big Bend and Fort Peck; therefore, significant impacts could occur in some areas due to the potential large adverse impacts on NED and RED within specific years.

Reservoir recreation losses (resulting mainly from lower reservoir levels during the summer in some periods following the spawning cue release) almost balance out lower river gains from a NED perspective, but annual average reductions in regional labor income in the reservoirs would be approximately $108,000 relative to Alternative 1. On average, the irrigation sector would lose $83,000 per year from a national economic perspective and $28,000 per year in labor income regionally.

Land ownership impacts may result in a decline in regional labor income of $6.2 million at the end of the implementation period (15 years) as land would be acquired for endangered species and not available for crop production. Under Alternative 2, local government revenues would decrease $786,000 relative to Alternative 1 at the end of the implementation period.

Relative to Alternative 1, the lowered winter flows of Alternative 2 would sometimes negatively impact water supply intakes, although the economic implications of this from the perspective of the MRRP are considered to be low (past and future river bed changes due to aggradation and degradation are thought to be dominant factors driving cost impacts to water supply). There could also be substantial temporary water quality impacts associated primarily with short-term increases in turbidity associated with large-scale habitat construction.

Evaluation Discussion

Alternative 2 is based on full implementation of the 2003 BiOp and appears to have a sufficient likelihood of effectiveness for endangered species to be a viable alternative.

Similar to Alternative 1, the acceptability of Alternative 2 would likely be varied based on Draft EIS comments. Given the scale of actions required under Alternative 2, and the resulting potential impacts as compared to Alternative 1, it is likely this alternative would not be acceptable to many stakeholders, Tribes, agencies, and the public. The high level of mechanical ESH construction in the Garrison reach for example would be a concern to Tribes due to potential impacts to cultural resources and the State of North Dakota due to recreation impacts during construction and concerns related to changed river geomorphology. In addition, releases exceeding channel capacity in the Garrison and Fort Randall reaches are of particular concern due to impacts to adjacent property. As modeled over the POR, Alternative 2 would cause an approximated increase of 427 additional days of channel capacity exceedance in the Fort Randall reach relative to Alternative 1. Alternative 2 could result in significant impacts to flood risk management in some areas in years where releases occur. Alternative 2 would result in adverse impacts across a broad range of river interests including potentially significant adverse impacts to cultural resources, thermal power, hydropower, and flood risk management in some areas during release years.

Although Alternative 2 may meet the species objectives, there is high uncertainty surrounding the benefits of the management actions included in this alternative. Without a systematic scientific AM program based on the results of the effects analysis, it would be an inefficient use of public resources and could actually impede learning and progress toward meeting the species objectives. In addition, Alternative 2 would be the most expensive alternative and there are less impactful means of meeting the species objectives. Therefore, Alternative 2 was not identified as the preferred alternative.

2.9.2.3 Alternative 3 – Mechanical Construction Only

Summary of Characteristics and Features

Alternative 3 includes the actions common to Alternatives 3–6 (including active AM; vegetation management, predator management, and human restriction measures on ESH; Level 1 and 2 studies; propagation and augmentation; spawning habitat and channel reconfiguration for IRCs). Under Alternative 3, USACE would create ESH through mechanical means at an average rate of 332 acres per year in the Garrison, Fort Randall, and Gavins Point river reaches in years when construction is needed. This amount represents the acreage necessary to meet the bird habitat targets after accounting for available ESH resulting from System operations. Alternative 3 would also include the provision for a one-time spawning cue test release from Gavins Point if the results of Level 1 studies during the first 9–10 years do not provide a clear answer on whether a spawning cue is important for pallid sturgeon.

Hydrologically, the effects of this alternative would be very close to those for Alternative 1 but without the specification for reoccurring spawning cue releases in March and May. Hydrological differences would be reduced flows relative to Alternative 1 in approximately 30 percent of years in late March and late April/early May, and corresponding increased flows relative to Alternative 1 during one or two weeks in October or November. The differences in magnitude of these flows would be small compared to those associated with the other alternatives. Alternative 3 would have less channel reconfiguration for pallid sturgeon early life stage habitat relative to Alternative 1, and this would have implications on flow routing and assumed stage-discharge relationships at certain locations.

Balance of Beneficial and Adverse Effects

Alternative 3 has a wide range of benefits relative to Alternative 1, including benefits to endangered species, reduced program expenditures, and increased performance for most HCs.

Modeling indicates that updated piping plover and least tern population persistence targets would be met under Alternative 3. Negligible temporary adverse impacts from ESH and IRC construction activities are expected. There could be long-term beneficial impacts from the creation of spawning sites and from IRC development although there is still high uncertainty regarding what is limiting pallid sturgeon recruitment. Long-term beneficial impacts to the species are anticipated from the implementation and adjustment of management actions within an active AM framework centered on the results of the effects analysis.

The reduction in the scale of early life stage pallid sturgeon habitat construction and greater use of structure modifications, rather than top-width widening and/or chute construction, relative to Alternative 1 would reduce overall program expenditures by $33.6 million per year on average from a NED perspective. This would reduce the need to purchase as much private land and increase crop production resulting in $843,000 more in labor income and $106,000 more in local tax revenue to local governments at the end of the implementation period.

The lack of a pallid sturgeon spawning cue release in Alternative 3 relative to Alternative 1 would result in benefits to a range of HCs. Comparatively small average annual net increases relative to Alternative 1 may be expected for hydropower, recreation (reservoir and river), navigation, thermal power, flood risk management, irrigation, water supply, and land ownership and management. Most of these have national, regional, and other social beneficial effects. A small increase in ecological services, fish and wildlife, and other special-status species and a small decrease in cultural resource site days at risk is indicated but these impacts are not considered significant.

The main adverse effects of Alternative 3 are related to a reduction in more than 577 habitat construction related jobs (which would result in a relative reduction in regional income of ($31.2 million per year for this item).

Evaluation Discussion

Alternative 3 would have beneficial impacts to most resources compared to Alternative 1. Some of the Tribes have expressed that the level of mechanical ESH construction in the Garrison reach is not acceptable and extensive coordination on site-specific construction activities to avoid sensitive areas in this reach would be an essential component of this alternative. Alternative 3 does not include a reoccurring flow action for the listed species; therefore, the channel capacity exceedances in the Garrison and Fort Randall reaches that are a concern under Alternatives 2, 4, 5, and 6 are not associated with Alternative 3. Alternative 3 is not expected to result in any significant adverse impacts.

Alternative 3 is a complete plan in that it meets USFWS's probability of persistence targets for piping plover and least terns. Alternative 3 would continue ongoing pallid sturgeon propagation activities, build spawning habitat as in-river test projects to learn if this action is effective, and build IRC habitat through structure modification and channel widening. It would also be implemented under an active AM framework for both the birds and pallid sturgeon.

Alternative 3 appears to be an acceptable plan due to its relative lack of adverse impacts compared to the other alternatives; however, several comments received during the public comment period indicate there are some who oppose Alternative 3 due to perceived impacts from management actions on their interests or because they believe Alternative 3 does not include enough habitat restoration or land acquisition. Given that an appropriate level of action is required for the listed species in order for USACE to comply with the ESA and continue to operate the System and maintain and operate the BSNP, Alternative 3 appears to be a workable and viable option. The ongoing engagement with MRRIC, Tribes, other agencies, and the public as site-specific management actions are implemented will help USACE identify remaining concerns and attempt to avoid and/or minimize impacts where possible.

Although Alternative 3 would not be the most efficient alternative from an overall NED standpoint, it is the second most efficient alternative from a NED perspective and its lack of adverse impacts compared to Alternative 1 is a good balance between overall efficiency and level of impacts to resources. There are uncertainties associated with its effectiveness in meeting the species objectives (in common with each alternative); however, Alternative 3 clearly demonstrates it would be the least impactful means of meeting species objectives across the full range of interests. USACE has completed ESA Section 7 consultation with USFWS on this alternative and received a no jeopardy finding in the BiOp (USFWS 2018) for least tern, piping plover, and pallid sturgeon. As a result, Alternative 3 would meet the species objectives and fulfill the purpose and need of the plan. Therefore, Alternative 3 has been identified as the **preferred alternative** in this MRRMP-EIS.

2.9.2.4 Alternative 4 – Spring ESH Creating Release

Summary of Characteristics and Features

In addition to a range of actions common to Alternatives 3–6, under Alternative 4, USACE would create ESH for the least tern and piping plover through mechanical means at an average rate of 195 acres per year in the Garrison, Fort Randall, and Gavins Point reaches in years when construction is needed. This amount of ESH represents the acreage necessary to meet the bird habitat targets after accounting for available ESH resulting from implementation of a spring ESH-creating reservoir release.

Alternative 4 reservoir operations would be similar to Alternative 1 with the addition of the spring ESH-creating release. In any year, the implementation of this release would occur if System storage is at 42 MAF or greater on April 1, natural flows creating 250 acres of ESH have not occurred in the previous 4 years, and downstream flow is below downstream flow limits specific to this alternative. If those conditions are met, the release would be implemented on April 1 with a release of up to 60 kcfs out of Gavins Point, and as often as every 4 years. To achieve the Gavins Point release, Fort Randall Dam releases would be increased a similar amount as Gavins Point and releases from Garrison Dam would be approximately 17.5 kcfs less than the Gavins Point release. The duration of the release could vary, but there would typically be 40 days when releases from Gavins Point are 60 kcfs.

Over the POR, modeling shows that a full release occurs in 9 out of 82 years, with a partial release (i.e., started but abandoned) occurring in 7 years. After the higher release period is completed, the upper three reservoirs have less water than they would have without the higher release, and they must recover. During this phase, releases are lower allowing more water to accumulate in the reservoirs. This refill period can last from a few months to several years. In some cases, a second flow release might begin before the System has fully refilled from the first.

Balance of Beneficial and Adverse Effects

The net benefits of Alternative 4 relative to Alternative 1 include the listed species, regional land ownership, net flood risk management benefits and reduced program expenditures from a national perspective. Modeling indicates that updated piping plover and least tern population persistence targets would be met under this alternative. For pallid sturgeon, long-term beneficial impacts may be expected from the creation of spawning sites and from IRC development although there is still high uncertainty regarding what is limiting pallid sturgeon recruitment. No negative impacts on pallid sturgeon are anticipated from the spring ESH-creating release. Long-term beneficial impacts to the species are anticipated from implementation and adjustment of management actions under an active AM framework.

Program expenditures under Alternative 4 would be the lowest of all alternatives, on average $37.5 million per year less than Alternative 1. Alternative 4 would have a smaller scale of early life stage pallid sturgeon habitat development relative to Alternative 1. This would reduce the need to purchase as much private land and increases in crop production resulting in $843,000 more in labor income and $106,000 more in local tax revenue to local governments at the end of the implementation period. There may be small benefits to fish and wildlife, and other special-status species.

The majority of the net impacts of Alternative 4 would be negative. Hydropower revenues would fall by an annual average of $3.7 million per year as the result of lower flow years during System refill phases, a small percentage decrease of the overall value although reductions in some years following releases would be in the tens of millions which is considered significant. Recreation as a sector would lose $1,100,000 on average per year from the national perspective and $585,000 per year in labor income regionally relative to Alternative 1. Most of these impacts would be from the upper three reservoirs (where summer elevations would more frequently be at lower than preferred levels), although lower river recreation may experience benefits from more preferable flow conditions and recreational opportunities offered by habitat creation. Compared to Alternative 1, irrigation and thermal power would be negatively affected on average by $69,000 and $3.1 million per year for NED impacts, respectively. Nationally, navigation losses would be $181,000 per year, and regional losses in labor income would be approximately $94,000 less per year relative to Alternative 1.

Under Alternative 4, flood damages were estimated to be $688,000 less per year in relative to Alternative 1, but some years would experience negative impacts in the tens of millions of dollars. Regionally, these impacts relative to Alternative 1 would result in an increase of $73,000 in average annual labor income. Other effects of Alternative 4 are related to a reduction in more than 631 habitat construction related jobs (which would result in a relative reduction in regional income of $33.8 million per year for this item).

Alternative 4 would additionally have small negative impacts to flood risk management, navigation, and water intakes on the Mississippi.

Evaluation Discussion

Increased flood risk management issues would be associated with spring releases. Although there may be some opportunities to reduce flood risk under real-time operation (refer to Chapter 5 in the SAMP), there will always be additional risk associated with increasing river flows during the spring period when tributary inflows are flashy and difficult to respond to in a timely way. As modeled over the POR, Alternative 4 would cause an increase of over 416 additional days of channel capacity exceedances in the Garrison Reach and 374 additional days in the Fort Randall reach relative to Alternative 1. Alternative 4 could result in significant impacts to flood risk management in some areas and hydropower in years where releases occur.

The acceptability of Alternative 4 appears to be varied, with comments on the Draft EIS ranging from concerns related to elevated flood risk to concerns about reduced habitat construction and land acquisition as compared to Alternative 1. Given the increased flood risk and impacts to hydropower under Alternative 4, and the resulting potential impacts as compared to Alternative 1, it is likely this alternative would not be acceptable to many stakeholders, Tribes, agencies, and the public.

Similar to Alternative 3, Alternative 4 is considered a complete plan in that it would meet USFWS probability of persistence targets for piping plover and least terns and would continue ongoing pallid sturgeon propagation activities, build spawning habitat as in-river test projects to learn if this action is effective, and build IRC habitat through structure modification and channel widening. It would also be implemented under an active AM framework for both the birds and pallid sturgeon.

Alternative 4 has benefits compared to Alternative 1 from a combined NED standpoint but its net average annual NED value is less than Alternatives 3, 5, and 6. The relative benefits to NED associated with this alternative are outweighed by a range of impacts to basin interests. Alternative 4 is potentially as effective in meeting the species objectives as Alternative 3, but the risk of significant adverse impacts are compelling reasons for not identifying Alternative 4 as the preferred alternative in the MRRMP-EIS.

2.9.2.5 Alternative 5 – Fall ESH Creating Release

Summary of Characteristics and Features

In addition to a range of actions common to Alternatives 3–6 under Alternative 5, USACE would create ESH for the least tern and piping plover through mechanical means at an average rate of 253 acres per year in the Garrison, Fort Randall, and Gavins Point reaches in years when construction is needed. This amount of ESH represents the acreage necessary to meet the bird habitat targets after accounting for available ESH resulting from implementation of a fall ESH-creating reservoir release.

Alternative 5 reservoir operations would be similar to Alternative 1 with the addition of the fall ESH-creating release. In any year, the implementation of this release would occur if the service level is at 35 kcfs or greater (54.5 MAF System storage) on October 17, natural flows creating 250 acres of ESH have not occurred in the previous 4 years, and downstream flow is below identified downstream flow limits. If those conditions are met, the release would be implemented on October 17 with a release of up to 60 kcfs out of Gavins Point Dam, and as often as every 4 years. To achieve the Gavins Point release, Fort Randall Dam releases would be increased a similar amount as Gavins Point and releases from Garrison Dam would be approximately 17.5 kcfs less than the Gavins Point release. The duration of the release could vary, but there would typically be about 40 days when discharges from Gavins Point Dam are 60 kcfs.

Over the POR, modeling shows that a full release occurs in 7 out of 82 years, with a partial release occurring in 2 years. After the higher release period is completed, the upper three reservoirs have less water than without the higher release, and they must recover. During this phase, releases are lower, allowing more water to accumulate in the reservoirs. This refill period can last from a few months to several years. In some cases, a second flow release might begin before the System has fully refilled from the first.

Balance of Beneficial and Adverse Effects

Relative to Alternative 1, Alternative 5 has a range of net benefits for listed species, net flood risk management, program expenditures, and regional land ownership.

Alternative 5 modeling indicates that updated piping plover and least tern population persistence targets would be met under this alternative. For pallid sturgeon, temporary negligible impacts from ESH and IRC construction activities are expected. Long-term beneficial impacts for pallid sturgeon could occur from the creation of spawning sites and IRC development although there is still much uncertainty regarding what is limiting pallid sturgeon recruitment. No negative impacts on pallid sturgeon are anticipated from the fall ESH-creating release. Long-term beneficial impacts to the species are anticipated from the implementation and adjustment of management actions within an active AM framework. There may be small but unquantified benefits to ecosystem services, fish and wildlife, and other special-status species.

Alternative 5 has program expenditures that would be $36.5 million less than Alternative 1 and would include a smaller scale of early life stage pallid sturgeon habitat development relative to Alternative 1. This would reduce the need to purchase as much private land and increase crop production resulting in $106,000 more in local tax revenue to local governments at the end of the implementation period.

Commercial navigation would have a net average annual NED that is $57,000 lower than Alternative 1, and would have a decrease in regional income by an average annual $9,000. Flood risk benefits from the national perspective are attributable to reduced damages relative to Alternative 1 in 44 out of the 82 years.

Relative to Alternative 1, Alternative 5 would have net adverse impacts to hydropower, recreation, irrigation, thermal power, navigation, and regional income from program expenditures. The reduced scale of habitat construction relative to Alternative 1 would result in a reduction in approximately 617 habitat construction related jobs (which would result in a relative reduction in regional income of $33.1 million per year for this item). The adverse average annual hydropower impacts resulting from Alternative 5 would be a fraction of 1 percent of the overall value of electricity generated although reductions in some years following releases would be in the tens of millions. The average annual benefit to thermal power would be approximately $1 million less than Alternative 1. Alternative 5 would have little net change for recreation, although impacts to upper reservoir recreation would be offset somewhat by gains to lower river recreation. There would be relatively small regional negative impacts associated with flood risk management and navigation in the average year relative to Alternative 1.

Evaluation Discussion

Alternative 5 results in net average annual benefits to flood risk management, thermal power, program expenditures, land ownership and tax revenues, and to listed species compared to Alternative 1. However, impacts of the ESH releases on flood risk management are a concern, particularly in the Garrison and Fort Randall Reaches, and net average annual benefits often mask more acute adverse impacts in release years or during System recharge periods. Likewise, although adverse impacts to hydropower on an average annual basis are a fraction of the total value of electricity generated, relatively severe adverse impacts occur in some years. In addition, over the POR used for modeling, Alternative 5 would cause an increase of 265 additional days of channel capacity exceedances in the Garrison Reach and 233 days in the Fort Randall reach relative to Alternative 1.

Similar to Alternative 3, Alternative 5 is considered a complete plan in that it would meet USFWS's probability of persistence targets for piping plover and least terns and would continue ongoing pallid sturgeon propagation activities, build spawning habitat as in-river test projects to learn if this action is effective, and build IRC habitat through structure modification and channel widening. It would also be implemented under an active AM framework for both the birds and pallid sturgeon (in common with Alternatives 3, 4, and 6).

The acceptability of Alternative 5 appears to be varied, with comments on the Draft EIS ranging from concerns related to elevated flood risk to concerns related to reduced habitat construction and land acquisition. Given the increased flood risk in release years under Alternative 5, and the resulting potential impacts as compared to Alternative 1, it is likely this alternative would not be acceptable to many stakeholders, Tribes, agencies, and the public.

Alternative 5 would be the most efficient alternative from a combined NED standpoint and would have an average annual NED value of $789,000 greater than Alternative 3. However, it would also have a larger negative regional impact compared to Alternative 3 of a roughly similar amount. Alternative 5 would potentially be as effective in meeting the species objectives as Alternative 3 but the additional channel capacity exceedances in the Garrison and Fort Randall Reaches and potential for adverse impacts to flood risk management and hydropower in some years when releases occur are reasons Alternative 5 was not identified as the preferred alternative for this MRRMP-EIS.

2.9.2.6 Alternative 6 – Pallid Sturgeon Spawning Cue

Summary of Characteristics and Features

In addition to a range of actions common to Alternatives 3–6, under Alternative 6, USACE would create ESH for the least tern and piping plover through mechanical means at an average rate of 246 acres per year in the Garrison, Fort Randall, and Gavins Point reaches. This amount represents the acreage necessary to meet the bird habitat targets after accounting for available ESH resulting from implementation of a Fall ESH-creating release.

Alternative 6 reservoir operations would be similar to Alternative 1 with the addition of an attempt, every 3 years, to perform a spawning cue release of a greater intensity than is currently defined in the Alternative 1 (subject to System storage requirements and flood control limits). The release would be bimodal, with a release in March that increases by 2,200 cfs per day until a target flow magnitude (double the navigation flow target that was set on day one of the release) is reached. The peak would be maintained 2 days, and afterwards flows would be reduced at a rate of 1,700 cfs per day until flow-to-target navigation release rates are met. The second release would begin in mid-May with the precise date determined by water temperature. Flows would be increased at a rate of 2,200 cfs per day until a peak magnitude equaling twice that of the first day of the release is reached; after holding this for 2 days, flows would be allowed to return to normal at a declining daily flow rate of 1,900 cfs per day. Based on HEC-ResSim POR simulations, Gavins Point releases during the May spawning cue would range from 50 to 67 kcfs. In the case of a failed completion of this sequence, an attempt would be made in the following year, subject to preclusions.

Over the POR, modeling shows that a full release sequence of the type described here occurs in 6 out of 82 years. In March, a partial (i.e., attempted but abandoned due to constraints) release occurs in 16 years and a full release occurs in 20 years. In May, a partial release occurs in 5 years and a full release occurs in 8 years. As with all other flow-release alternatives, after the higher flow period in the river is completed, a refill period begins in which the upper three reservoirs have less water than otherwise would have been the case, and must be refilled. During this phase, releases are lower than they otherwise would have been, allowing more water to accumulate in the reservoirs. This refill period can last from a few months to several years. In some cases, a second flow release might begin before the System has fully refilled from the first.

Balance of Beneficial and Adverse Effects

Modeling indicates that updated population persistence targets for piping plover and least tern would be met under Alternative 6. For pallid sturgeon, temporary negligible impacts from ESH and IRC construction activities are expected. Long-term beneficial impacts for pallid sturgeon could occur from the creation of spawning sites and IRC development although there is still high uncertainty regarding what is limiting pallid sturgeon recruitment. There would be possible beneficial impacts from the spawning cue release, although evidence is currently lacking to confirm or quantity any level of benefit. Long-term beneficial impacts to the species are anticipated from the implementation and adjustment of management actions within an active AM framework. There may be small ecosystem services and fish and wildlife benefits.

Alternative 6 has program expenditures that would be $36.6 million less than Alternative 1 and in common with Alternatives 3, 4, and 5, Alternative 6 would have a smaller scale of early life stage pallid sturgeon habitat development relative to Alternative 1. This would reduce the need to purchase as much private land and increase crop production resulting in $843,000 more in labor income and $106,000 more in local tax revenue to local governments at the end of the implementation period. There would be an average annual decrease in hydropower value of $3.2 million, and there would be an annual financial loss of $792,000 in a typical generation year for the Western Area Power Administration (WAPA).

The majority of the net impacts of Alternative 6 would be negative. Recreation as a whole would lose $846,000 per year from the national perspective and $511,000 per year on average in regional labor income. Most of these impacts would be from the upper three reservoirs (where summer elevations are more frequently at lower than ideal levels), although lower river recreation may experience benefits from more preferable flow conditions and recreational opportunities offered by habitat creation. Irrigation and navigation would be negatively affected on average by $115,000 and $127,000 per year, respectively, from a national perspective, and by $30,000 and $85,000 in decreased regional income. Alternative 6 would adversely impact cultural resources by increasing sites affected in the reservoirs compared to Alternative 1. The adverse average annual hydropower impacts resulting from Alternative 6 would be a fraction of 1 percent of the overall value of electricity generated, although reductions in some years following releases would be in the tens of millions which is considered significant.

Impacts to flood risk management would increase under Alternative 6. Modeling suggests an average annual increased flood damage of $283,000 nationally and a decrease in average annual labor income of $65,000 regionally.

Evaluation Discussion

Alternative 6 results in negative impacts to a wide range of interests in the basin. Increased flood risk management issues are associated with releasing water in the spring. Although there may be some opportunities to reduce flood risk under real-time operation (refer to Chapter 5 in the SAMP), there will always be additional risk associated with increasing river flows during the spring period when tributary inflows are flashy and difficult to respond to in a timely way. As modeled over the POR, Alternative 6 caused an increase of 541 additional channel capacity exceedances in the Fort Randall reach relative to Alternative 1.

Similar to Alternative 3, Alternative 6 is considered a complete plan because it would meet USFWS's probability of persistence targets for piping plover and least terns and would continue ongoing pallid sturgeon propagation activities, build spawning habitat as in-river test projects to learn if this action is effective, and build IRC habitat through channel modifications. It would also be implemented under an active AM framework for both the birds and pallid sturgeon.

The acceptability of Alternative 6 appears to be varied, with comments on the Draft EIS ranging from concerns related to elevated flood risk to concerns related to reduced habitat construction and land acquisition. Given the increased flood risk under Alternative 6, and the resulting potential impacts as compared to Alternative 1, it is likely this alternative would not be acceptable to many stakeholders, Tribes, agencies, and the public.

Alternative 6 is a fairly efficient alternative from a combined NED standpoint but has a net average annual value less than Alternatives 3 and 5. The relative benefits to NED associated with this alternative do not appear to be worth the broad range of often severe negative impacts to basin interests. Alternative 6 incorporates a spawning cue flow for pallid sturgeon; however, there is currently no scientific evidence that pallid sturgeon would benefit from such a flow and therefore Alternative 6 is not considered more effective in meeting the species objectives than Alternative 3.

Because of the risk of adverse impacts and the effectiveness and efficiency of Alternative 6 is not substantially different from Alternative 3, Alternative 6 was not identified as the preferred alternative for this MRRMP-EIS.

2.10 Summary of Preferred Alternative

This section summarizes the description of the preferred alternative and explains components that were further refined during coordination with USFWS. Chapter 4 provides a more detailed description of how the preferred alternative would be implemented under the SAMP. The preferred alternative includes the initial set of actions that USACE would implement over the 15-year implementation period and monitoring and evaluation as described in the SAMP. The SAMP includes a suite of in-river management actions (Level 3), in-river test projects (Level 2), and research and monitoring (Level 1) aimed at achieving the objectives for the interior least tern, piping plover, and pallid sturgeon. As described in Section 2.9, the initial set of actions were chosen after careful consideration of species needs, critical management uncertainties, and anticipated impacts to authorized purposes and other socioeconomic impacts. The preferred alternative incorporates the proposed action in the 2017 BA and incorporates the 2018 BiOp.

2.10.1 Pallid Sturgeon

- **Propagation and Augmentation**: Continue with Level 3 propagation and stocking actions in both the upper and lower river based on the PSCAP. Level 1 studies will include: engineering feasibility of hatchery needs, facilities, operations; retrospective analysis of survival linked to hatchery operations; and simulation models of population sensitivity to size, health, and genetics. Level 2 studies will consist of field experimentation with varying size and location of stocking based on agreed upon needs with USFWS and following the guidance in the USFWS Propagation Plan.
- **Population and Assessment Project Monitoring**: The PSPAP would continue in some form in both the upper and lower river. Some level of redesign of the PSPAP is anticipated in order to achieve efficiencies and align the PSPAP with the SAMP. Data collected through the PSPAP are used to evaluate propagation and augmentation and provide long-term assessment of fish habitat and population metrics. USACE has developed partnerships with state and federal agencies already active on the Missouri and Kansas Rivers and has provided the funding, standardized protocols, and quality control oversight necessary to implement the monitoring strategy of the PSPAP.

2.10.1.1 Upper River

The following actions in the upper river will be immediately implemented and monitoring of whether fish passage at Intake is successful will be undertaken by the Bureau of Reclamation in coordination with USACE.

- **Level 1 Research and Monitoring**: In addition to research and monitoring regarding propagation and augmentation which were previously described, research and monitoring will be implemented to address the following uncertainties:
    - **Spawning Cues**: Design complementary passive or active telemetry approach which can monitor reproductive behaviors opportunistically (no intentional spawning cue releases). Conduct opportunistic tracking of reproductive behaviors.
    - **Temperature Manipulation**: Field study of Lake Sakakawea conditions limiting age-0 survival; study of development rates of embryos, free embryos, and larvae; larval drift study.
    - **Drift Dynamics**: Model integration for drift and development; modeling location and rate of change of Lake Sakakawea headwaters; increase understanding of patchiness of anoxic zone in Lake Sakakawea; spawning habitat distribution on

the Yellowstone River; field experiment drift/dispersal, advection/dispersion validation to refine drift model; mesocosm studies to quantify transport.

A description of these research and monitoring activities is included in Chapter 4 and Appendix C of the SAMP (Detailed Description of Level 1 and Level 2 Science Components). After this research and monitoring the intent is to follow the decision criteria and governance process described in Chapter 4 of the SAMP to guide implementation of subsequent activities.

2.10.1.2 Lower River

- **Spawning Habitat**: Level 1 studies would consist of investigation of functional spawning habitat in the Yellowstone River for potential replication, field gradient studies of habitat conditions, and mesocosm studies on spawning conditions and behaviors.

  Level 2 actions would include engineering studies for sustainable design and implementation and manipulative field experiments for spawning habitat. Up to three spawning habitat sites would be created and monitored for effectiveness in terms of relative use of these sites compared to other control areas, and the relative spawning success, as determined by hatch rate, catch per unit effort of free embryos and other indicators.

- **Channel Reconfiguration for IRC Habitat**: Level 1 studies would consist of screening regarding limitations of food or forage habitats and technology development for IRC sampling, modeling, and measurement.

  Level 2 in-river test projects would consist of manipulative field experiments with IRCs; Appendix E of the SAMP presents a hierarchical staircase study design to evaluate the response of age-0 sturgeon catch to IRC habitat development activities. Twelve pairs, consisting of experimental and control sites, would be used in the experiment over a period of 6–7 years. It is estimated that the twelve experimental sites would meet the habitat targets for this time period (stage 1 and 2) as described in the USFWS Planning Aid Letter dated September 14, 2016. If results remain equivocal following this experiment, additional field experiments would be implemented at a level designed to resolve uncertainties regarding the importance of IRC habitat to the survival of age-0 sturgeon in an expedited manner. This would contribute in meeting the Level 3 habitat targets described in the Planning Aid Letter for the following 4 years (stage 3).

  In addition to the experimental studies described previously and to the extent possible and where appropriate, the remaining Level 3 habitat recommendations outlined in the Planning Aid Letter for stage 3 would be met through Level 2 or 3 projects to modify existing SWH project sites which are not meeting IRC habitat criteria. If the designs are successful in increasing interception, interception continues to be hypothesized as limiting, and food and foraging habitat also continue to be hypothesized or proven to be limiting, then sites would be constructed at a rate to meet the Level 3 habitat targets.

- **Spawning Cue Release**: The spawning cue release currently included in the Master Manual would no longer occur under the preferred alternative because that particular frequency, magnitude, and duration of release has not been effective in causing upstream movements, aggregation of spawning adults, and spawning. Level 1 studies would consist of designing a complementary passive telemetry network or relying on continuation of active telemetry depending on feasibility and relative cost effectiveness. The opportunistic tracking of reproductive behaviors associated with monitored hydrologic characteristics would be implemented to answer uncertainties regarding the importance of a spawning cue to pallid sturgeon recruitment. Obtaining a clear answer to this question depends on there being a wide enough variation (or contrast) in flow patterns across years, and a large enough number of tracked fish, to make meaningful comparisons.

- If Level 1 studies support the need for a managed pulse from Gavins Point Dam, a Level 2, one-time spawning cue test release would be implemented. The timing, magnitude, and duration of a spawning cue test release would be based on the best available science at the time of implementation (October 2017 Biological Assessment). It was assumed the test release would be similar in magnitude and duration to the flow release which was included as a recurring release under Alternative 6, which includes both an early spring and late spring spawning cue release. The analysis of the 82-year POR shows approximately a 7% probability (6 out of 82 years) of implementing both an early spring and late spring spawning cue to completion in any given year to the criteria established for Alternative 6. If Level 1 studies support a timing consistent with only one or the other periods from Alternative 6, the probability increases to approximately 24% (20 of 82 years) and 10% (8 in 82 years) in any given year for an early spring or late spring spawning cue ran to completion, respectively. Additionally, for a single year test, it is possible that the spawning cue release may be implemented and stopped, resulting in only a partial test, if downstream flows increase above the Alternative 6 limits as would have occurred in approximately 20% and 6% of the 82-year POR for the early spring and late spring spawning cues, respectively. If a partial release is implemented and later stopped due to downstream flood limits outlined in Alternative 6, additional attempts to implement a flow test may be required.

  Following a review of these releases which were modeled under Alternative 6 over the POR, actions necessary to avoid or minimize potential impacts were identified. Most notable impacts are related to the potential for out of bank occurrences downstream of Fort Randall and Gavins Point Dams because releases from Oahe, Fort Randall, and Gavins Point Dams would be used to generate the spawning cue. Real-time careful consideration of precipitation forecasts and resulting downstream tributary inflow would be necessary in order to plan releases to avoid flooding potential downstream of Gavins Point Dam. However, since this release is above current channel capacity in the Fort Randall reach some impacts to private lands would likely occur. In addition, the ability to mitigate impacts by using downstream inflow forecasts is limited by the travel time downstream of Gavins Point Dam and the reduced forecast accuracy 5 to 7 days in the future. USACE has sought to minimize this impact as much as possible in the very selection of this alternative. USACE will continue to effectively strategize how to minimize the impacts over the next 9 years should this test be required. The single year impacts of a partial or fully implemented pulse would be expected within range of the years where a pulse was implemented in Alternative 6. It would also be advisable to avoid this release when System storage levels are close to navigation preclusions to avoid impacts to navigation.

- **Level 1 Research and Monitoring**: In addition to research and monitoring regarding propagation and augmentation which were previously described, research and monitoring will be implemented to address the following uncertainties:
  - Temperature Control: Model water temperature management options, Fort Randall.
  - Drift Dynamics: Technology development: surrogate particles, particle tracking, learning from results of upper river drift tests; Field studies: Resilience, stamina in turbulent flows (lab or mesocosm study); Field studies on free embryo exit paths; Field gradient study, age-0 survival and complexity; Free embryo transport to

Mississippi River (contingent on ongoing microchemistry work); Field experiments with particle tracking, embryos, and models

A description of these research and monitoring activities is included in Chapter 4 and Appendix C of the SAMP (Detailed Description of Level 1 and Level 2 Science Components). After this research and monitoring, the intent is to follow the decision criteria and governance process described in Chapter 4 of the SAMP to guide implementation of subsequent activities.

2.10.2 Least Tern and Piping Plover

The following is a summary of the initial set of actions to be implemented for the piping plover and least tern under the preferred alternative.

- **Mechanical ESH Construction**: This would include implementation of mechanical ESH creation in the Garrison, Fort Randall, and Gavins Point reaches to meet the standardized and available ESH targets specified by USFWS and described in Section 1.4.2. Based on hydrology and hydraulics modeling coupled with tern and plover population models this would result in constructing an average of 332 acres of ESH per year. In real-time, the existing population and ESH status would be assessed, as described in the SAMP, to determine actual annual construction needs based on trends in the population and ESH. This action would require extensive coordination with the Tribes in developing site-specific plans for construction in the Garrison reach in order to avoid sensitive areas.
- **Reduced Nesting-Season Flow Releases within Capability Provided in Current Master Manual**: Flexibility under the existing Master Manual to allow reduction in releases when no navigation traffic is scheduled can be used to extend the life of ESH for nesting terns and plovers.
- **Flow Management to Reduce Take**: The steady release-flow to target operation under the existing Master Manual during the nesting season would continue. This involves releasing less water when possible to avoid flooding tern and plover nests below the dams. Regular communication between USFWS and reservoir control staff currently occur for this purpose and would continue.
- **Predator Management and Human Restrictions Measures**: Predator management and human restriction measures would continue on constructed and naturally created sandbars. Predator management would follow the existing plan for predator management developed by USACE in 2009. Proposed management actions in the plan include the use of exclusion cages and exclusion fending to protect nests and hazing of predators in combination with audio or visual frightening devices to deter predators away from nesting sites. There would be lethal and non-lethal removal of individual target predators that have the greatest impact on least tern and piping plover nests and chicks, particularly raccoons, coyotes, mink, and great horned owls. Human restriction measures include fencing of nesting areas or signage to alert people of the presence of nesting birds.
- **Vegetation Management**: Vegetation management would continue to follow the existing vegetation management strategies as explained in the 2013 Environmental Assessments for vegetation management in Nebraska-South Dakota, and North Dakota. The primary method of vegetation removal from selected sandbars would be spraying from an all-terrain vehicle or hand spraying for smaller areas with less vegetation. In areas that are large or densely vegetated, aerial spraying from a helicopter would be

conducted. USACE would continue to use an imazapyr-based (e.g., Habitat) and/or a glyphosate-based (e.g., Rodeo) herbicide approved by the U.S. Environmental Protection Agency (EPA) for aquatic use. Additional vegetation removal activities may include cutting, mulching, disking, mowing, raking, and removing vegetation from sandbars. The ESH interagency team will continue to meet annually to discuss locations on the river where vegetation treatment should be conducting in an effort to maintain as much ESH as possible while considering other competing needs such as the regeneration of cottonwoods.

- **Monitoring**: Annual productivity monitoring of least tern and piping plover populations on the reservoir and river reaches of the Missouri River Mainstem would continue. The current monitoring focuses on an adult census, measurement of fledge ratios, and documentation of incidental take if applicable. ESH habitat quality monitoring and assessment of management actions to determine their effectiveness would also occur. In addition, focused research projects on various aspects of piping plover demographics and habitat use would be implemented based on the prioritization process developed for the SAMP.
- **Research and Modeling**: Modeling and research would also occur related to ESH construction, habitat-creating flow releases, lowered nesting season flow releases, flow releases to reduce take, sandbar augmentation and modification, vegetation management, predation control, human restriction measures, and reservoir water-level management. A detailed listing of the associated management questions and study summaries can be found in Chapter 3 of the SAMP.