Missouri River Recovery Program

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Missouri River Recovery Management Plan and Environmental Impact Statement

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Missouri River Recovery Management Plan and Environmental Impact Statement

Volume 2

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3.0 Affected Environment and Environmental Consequences

3.1 Introduction

This chapter presents both the affected environment and environmental consequences, as required by the National Environmental Policy Act (NEPA). This chapter is organized by resource topic with the status of the affected environment and the impacts of each alternative described within each resource section. The affected environment sections provide a description of different aspects of the human environment that may be affected by the alternatives. The environmental consequences sections provide a description of the impact assessment methodologies, direct and indirect impacts, and how these impacts might change based on climate change. Resource impacts specific to the Tribes are discussed within each applicable resource section. Cumulative impacts are described at the end of each resource topic.

Adverse environmental effects which cannot be avoided, the relationship between short-term uses of the environment and long-term productivity, and any irreversible or irretrievable commitments of resources are presented in separate sections at the end of the chapter.

The Council on Environmental Quality (CEQ) Regulations Implementing NEPA defines the following impact categories:

- **Direct impacts**: caused by an action included in a plan alternative and occurring at the same time and place.
- **Indirect Impacts**: caused by an action included in a plan alternative, but would occur later in time or further removed in distance.
- **Cumulative Impacts**: caused from incremental impact of an action added to other past, present, and reasonably foreseeable future actions.

Impacts are described as either *beneficial* or *adverse*. Beneficial impacts result in a positive change in the condition of the resource when compared to the No Action alternative. Adverse impacts result in a negative change in the condition of the resources when compared to the No Action alternative. Impacts are also described in terms of duration. *Temporary* impacts would not persist long after implementation of the management action. *Long-term* impacts would be permanent or continuous over the period of analysis.

Finally, impacts are described in relation to their significance. The CEQ regulations require consideration of both context and intensity when determining the significance of an impact on a resource. Context means considering the extent of the impact such as in a national, regional, or local setting.

The following factors can be considered in determining the severity of impact (40 CFR 1508.27):

- Impacts that may be both beneficial and adverse. A significant effect may exist even if the federal agency believes that on balance the effect will be beneficial.
- The degree to which the proposed action affects public health or safety.

- Unique characteristics of the geographic area, such as proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas.
- The degree to which possible effects on the human environment are uncertain or involve unique or unknown risks.
- The degree to which the action may establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration.
- Whether the action is related to other actions with individually insignificant but cumulatively significant impacts. Significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment. Significance cannot be avoided by terming an action temporary or be breaking it down into small component parts.
- The degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or may cause loss or destruction of significant scientific, cultural, or historic resources.
- The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act.
- Whether the action threatens a violation of federal, state, or local law or requirements imposed for the protection of the environment.

The following descriptors are used in the body of this chapter for consistency in describing impact intensity in relation to significance.

- **No or Negligible Impact**: The action would result in no impact or the impact would not change the resource condition in a perceptible way.
- **Small Impact**: The effect to the resource would be perceptible; however, in context the impact would not be severe.
- **Large Impact**: The effect to the resource would be perceptible and in context the impact may be severe.

The rationale for why an impact is considered to fall under one of the preceding descriptors is included in each resource section. Statements of significance are supported by text describing the context and intensity of the impact and are summarized in the “Conclusion” section under each resource topic.

3.1.1 Impact Assessment Methodology

The management actions in this draft EIS that could impact the human 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 (refer to Section 3.2.1.1) Therefore, the discussion of potential impacts for many resources includes an analysis based on the results of modeling the alternatives over an 82-year hydrologic period of record (1931−2012) (POR) for the Missouri River basin.

The U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center (HEC) Reservoir System Simulation (HEC-ResSim) model was used to simulate reservoir operations for each of the alternatives (Figure 3-1). HEC-ResSim simulated System operation using the “rules” (described in Section 2.8) for each of the alternatives assuming the current reservoir System was in place for the entire POR and the same runoff conditions that occurred over the POR. The runoff conditions for the POR were adjusted to account for the current level of depletions. The outputs from HEC-ResSim are reservoir releases and elevations for each of the reservoirs for each of the alternatives. The outputs are labeled in terms of data simulation years, (1931, 1932…2012). Thus, 1945 output is the result of simulating how the System would be operated under each of the alternatives if the water that entered the river in 1945 (adjusted for current depletions) were to occur again.

The USACE HEC River Analysis System (HEC-RAS) model uses the outputs of HEC-ResSim 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. These cross sections were based on 2012 channel geometry and revised to reflect extent of early life stage pallid habitat for each alternative (described in Section 2.8). It was assumed this revised geometry was in place every year of the POR. The geometry does not include any forecast of the extent of channel aggradation or degradation that might occur in the future. It is important to compare the effects of the alternatives based on conditions that are relevant to the near-term (15-year) implementation timeframe of this planning process. Therefore, speculation on the exact extent of long-term channel aggradation or degradation that might occur and which is not associated with the management actions included in the alternatives was not attempted. A qualitative assessment of aggradation and degradation that might be associated with the alternatives is included in Section 3.2.2.

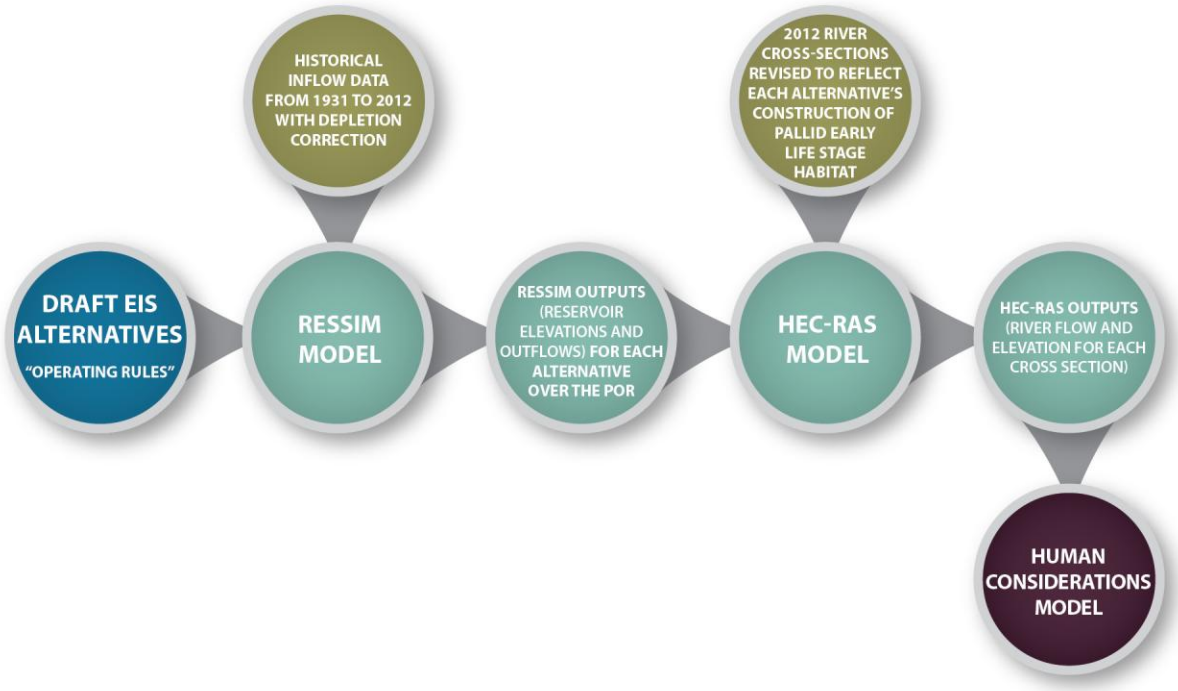


Figure 3-1. Model Outputs for the Missouri River Recovery Plan – Environmental Impact Statement

One might expect the modeling output for the No Action alternative (which reflects existing operation of the System and current implementation of Missouri River Recovery Program (MRRP) actions) from either HEC-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. For additional details describing the HEC-ResSim or HEC-RAS modeling, refer to the technical reports available on the MRRP website at www.moriverrecovery.org.

The outputs of the modeled alternatives are the result of very prescriptive modeling rules that attempted to simulate how management actions might be implemented in order to compare the effects of the alternatives with the variation in hydrology over the POR. In actual operation under active adaptive management, management actions would be implemented on a basis that is more flexible and responsive to on-the-ground conditions that cannot be modeled. For example, releases to create bird habitat are included in some of the draft EIS alternatives; these releases were modeled to take place at a set frequency that was estimated to be required to replace

habitat that would be eroded or rendered unusable due to vegetation encroachment. In actual operation, decisions would be made on an annual basis and consider whether species status, habitat conditions, and hydrologic conditions were suitable for a release.

3.1.2 "Human Considerations" and USACE Planning Accounts

The term "human considerations" refers to the interests of people within the basin. These include the authorized purposes as well as the many other services afforded by the System. The USACE and U.S. Fish and Wildlife Service (USFWS) have worked closely with the Missouri River Recovery Implementation Committee (MRRIC) since January 2013 to identify the underlying interests referred to as human considerations. Human considerations 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, the USACE asked the MRRIC and their constituents to provide input on the human considerations relative to their use of the Missouri River and its resources. The 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. The MRRIC formed the Human Considerations Ad Hoc Working Group as a mechanism to provide input on human considerations. The working group gathered and reviewed input from MRRIC members on the following human considerations: 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.

Effects to human considerations can be categorized into the "accounts" established in USACE planning policy to facilitate evaluation and display of the effects of alternative plans. These accounts are: national economic development (NED), environmental quality (EQ), regional economic development (RED), and other social effects (OSE). These accounts encompass the effects of the alternative plans as required by NEPA. The EQ account shows effects on ecological, cultural, and aesthetic attributes of natural and cultural resources that cannot be measured in monetary terms. The OSE account shows urban and community impacts on life, health, and safety. The NED account shows effects on the national economy. The RED account shows the regional incidence of NED effects, income transfers, and employment effects (U.S. Water Resources Council 1983). Multiple resource topics other than those categorized as human considerations were identified and are presented in this chapter.

The Missouri River Recovery Management Plan – Environmental Impact Statement (MRRMP-EIS) project delivery team (PDT) developed a suite of models (refer to Section 2.4) for use in assessing the effects of management actions to the human considerations. These models guided alternative development with the MRRIC. Additional economic models were developed to calculate the NED and RED effects of each alternative carried forward for detailed consideration in this draft MRRMP-EIS consistent with USACE planning requirements. The models used to evaluate each human consideration are described in a series of technical reports available on the MRRP website at www.moriverrecovery.org.

3.1.3 Cumulative Impacts

The CEQ regulations for implementing NEPA require an assessment of cumulative impacts in the decision-making process. This section describes the methods for identification of cumulative actions and presents the results of the cumulative impact analysis. CEQ defines a cumulative impact as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless

of what agency (Federal or non-Federal) or person undertakes such other actions" (40 CFR 1508.7)

The cumulative action identification and analysis methods are based on the policy guidance and methodology originally developed by CEQ (1997) and an analysis of current case law. Cumulative impacts were determined by adding the impacts of the alternatives being considered with other past, present, and reasonably foreseeable future actions. A process based on four primary steps was employed to assess the cumulative impacts of the alternatives.

Step 1: Identify Affected Resources

In this step, each resource affected by any of the alternatives is identified. Cumulative impacts were considered for each resource identified in this chapter.

Step 2: Establish Boundaries (Geographic and Temporal)

In identifying past, present, and reasonably foreseeable actions to consider in the cumulative impact analysis, affected resource-specific spatial and temporal boundaries were identified. The spatial boundary is where impacts to the affected resource could occur from the proposed alternatives and therefore where past, present, and reasonably foreseeable future actions could contribute to cumulative impacts to the affected resource. This boundary is defined by the affected resource and may be a different size than the proposed project area.

The temporal boundary describes how far into the past and forward into the future actions should be considered in the impact analysis. The temporal boundary is guided by CEQ guidance on considering past action and a rule of reason for identifying future actions.

For each resource topic, the geographic and temporal boundaries were identified. For all resource topics, the consideration of past actions is reflected in the existing condition. A default future temporal boundary of 50 years from the baseline condition was used as an initial timeframe; however, the impacts are based on their likelihood of occurring and whether they can be reasonably predicted.

Step 3: Identify the Cumulative Action Scenario

In this step, past, present, and reasonably foreseeable future actions to be included in the impact analysis for each specific affected resource were identified. These actions fall within the spatial and temporal boundaries established in Step 2. For a description of the cumulative actions considered see Appendix C: Cumulative Actions Descriptions.

Step 4: Analyze Cumulative Impacts

For each resource, the actions identified in Step 3 are analyzed in combination with the impacts of the alternatives being evaluated. This analysis describes the overall cumulative impact related to each resource and the contribution to this cumulative impact of each alternative being evaluated.

Table 3-1 indicates which resources are affected by each action. These cumulative actions are described further in Appendix C: Cumulative Actions Descriptions.

Table 3-1. Cumulative Actions and Potential Impacts to Resources in the Project Area

	Type			Affected Resource																							
Cumulative Action	Past	Present	Reasonably Foreseeable Future Actions	River Infrastructure/ Hydrology	Pallid Sturgeon	Piping Plover	Interior Least Tern	Fish and Wildlife Habitat	Other Special-Status Species	Water Quality	Air Quality	Cultural Resources	Land Use and Ownership	Commercial Dredging	Flood Risk Management	Hydropower	Irrigation	Navigation	Recreation	Thermal Power	Water Supply	Wastewater	Tribal Interests (Other)	Human Health and Safety	Environmental Justice	Ecosystem Services	Mississippi River Resources
Missouri River Mainstem Reservoir System Construction	X			X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
Bank Stabilization and Navigation Project Construction	X			X	X	X	X	X	X	X		X	X	X	X			X	X	X	X	X	X		X	X	X
Missouri River Bed Degradation/ Aggradation	X	X	X	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X		X	X	
Missouri River Depletions for Agriculture, Municipal, and Industrial Use	X	X	X	X				X	X	X			X	X	X	X	X		X	X	X	X	X		X	X	X
Oil/Natural Gas Production	X	X	X			X	X	X	X	X	X	X											X		X		
Groundwater Withdrawal Practices	X	X	X	X				X	X	X									X							X	X

	Type			Affected Resource																							
Cumulative Action	Past	Present	Reasonably Foreseeable Future Actions	River Infrastructure/ Hydrology	Pallid Sturgeon	Piping Plover	Interior Least Tern	Fish and Wildlife Habitat	Other Special-Status Species	Water Quality	Air Quality	Cultural Resources	Land Use and Ownership	Commercial Dredging	Flood Risk Management	Hydropower	Irrigation	Navigation	Recreation	Thermal Power	Water Supply	Wastewater	Tribal Interests (Other)	Human Health and Safety	Environmental Justice	Ecosystem Services	Mississippi River Resources
Floodplain Animal Pasturing/ Grazing	X	X	X					X	X										X							X	X
Floodplain Development (Urban, Residential, Commercial, Industrial)	X	X	X	X	X			X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X
Crop Production	X	X	X					X	X	X														X		X	X
Levee Construction	X	X	X	X	X			X	X	X		X			X				X							X	X
Fishery Stocking and Management	X	X	X		X			X	X										X				X			X	
Snag Removal	X	X	X	X	X			X	X	X					X			X	X				X				
Transportation and Utility Corridor Development	X	X	X		X			X	X	X	X	X	X	X	X	X		X	X	X			X			X	
USACE Continuing Authority Programs	X	X	X					X	X										X							X	

	Type			Affected Resource																							
Cumulative Action	Past	Present	Reasonably Foreseeable Future Actions	River Infrastructure/ Hydrology	Pallid Sturgeon	Piping Plover	Interior Least Tern	Fish and Wildlife Habitat	Other Special-Status Species	Water Quality	Air Quality	Cultural Resources	Land Use and Ownership	Commercial Dredging	Flood Risk Management	Hydropower	Irrigation	Navigation	Recreation	Thermal Power	Water Supply	Wastewater	Tribal Interests (Other)	Human Health and Safety	Environmental Justice	Ecosystem Services	Mississippi River Resources
Management of USACE Project Properties	X	X	X					X	X										X							X	
Regulating Works Project	X	X	X																								X
USFWS National Wildlife Refuge System Lands Management	X	X	X	X	X			X	X	X	X								X				X	X		X	
USFWS Aquatic Invasive Species Program	X	X	X		X	X	X	X	X										X							X	
NRCS Easement Programs	X	X	X	X				X	X	X			X						X				X	X		X	
NRCS Technical and Financial Assistance Programs	X	X	X					X	X	X	X		X						X				X			X	

	Type			Affected Resource																							
Cumulative Action	Past	Present	Reasonably Foreseeable Future Actions	River Infrastructure/ Hydrology	Pallid Sturgeon	Piping Plover	Interior Least Tern	Fish and Wildlife Habitat	Other Special-Status Species	Water Quality	Air Quality	Cultural Resources	Land Use and Ownership	Commercial Dredging	Flood Risk Management	Hydropower	Irrigation	Navigation	Recreation	Thermal Power	Water Supply	Wastewater	Tribal Interests (Other)	Human Health and Safety	Environmental Justice	Ecosystem Services	Mississippi River Resources
NPS Missouri National Recreation River Management Actions	X	X	X	X	X	X	X	X	X	X									X				X			X	
EPA Section 319 Non-Point Source Grant Program	X	X	X							X																	
Tribal Programs and Actions	X	X	X					X																			
Comprehensive Wildlife Conservation Plans and Protected Natural Areas	X	X	X					X			X								X				X	X			
Yellowstone Intake Diversion Dam Modification	X	X	X		X			X	X																		

3.2 River Infrastructure and Hydrologic Processes

3.2.1 Affected Environment

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. River flows are made up of base and peak flows. Base flow consists of groundwater discharge and the drainage of soil moisture from the surrounding watershed of the Missouri River and its numerous tributaries. Unregulated peak flow consists of distinct pulses of higher discharge as a result of large rainstorms and snow melting periods in spring and early summer. The magnitude, frequency, timing, duration, and rates of change of river flows affect geomorphology, chemistry, human uses, and the biological processes in the Missouri River.

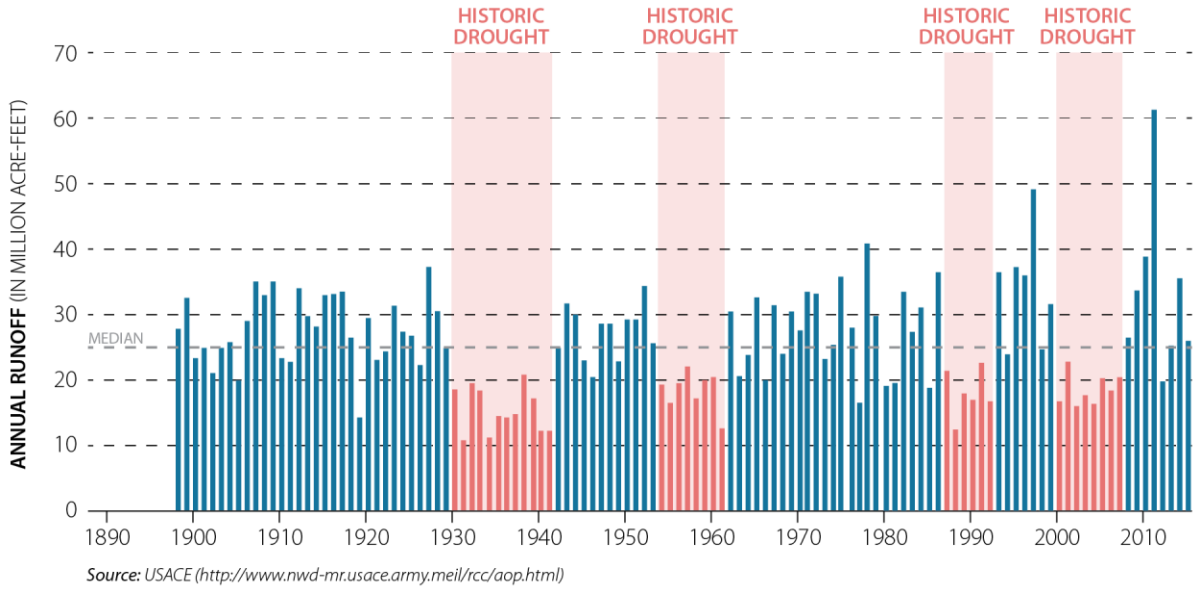
3.2.1.1 Basin Overview

The Missouri River is the longest river in the United States, draining one-sixth of the country. The river extends 2,341 miles from Three Forks, Montana at the confluence of the Jefferson, Madison, and Gallatin Rivers, to the confluence with the Mississippi River at St. Louis, Missouri (Figure 1-2). USACE and many other federal, state, and local agencies have constructed numerous water resource development projects within the Missouri River basin.

The Missouri River watershed covers an area of 529,350 square miles. The broad range in latitude, longitude, and elevation of the river basin and its location near the geographical center of the North American continent result in a wide variation of climatic conditions. Average annual precipitation ranges from as little as 8 inches in the northern Great Plains to as much as 40 inches in the higher elevations of the Rocky Mountains and in the southeastern portion of the basin.

The flows of the Missouri River have been altered by the numerous USACE projects with construction starting as early as the 1800s. Primary alterations include dams and reservoirs, flow regulation, channelization, and bank stabilization. Channelization has altered the river cross section and increased the depth and flow velocity within the river channel on average compared to the pre-channelization river. The stabilized channel, levees, and riverbed degradation (lowering) have reduced both the connection of the river with the floodplain and the amount of groundwater recharge in the remaining floodplain. In river segments with a degraded riverbed, the groundwater table has dropped.

Total annual runoff from the Missouri River varies considerably from year to year because of large variations in precipitation. Annual runoff, as measured above Sioux City (Figure 3-2) with adjustments for depletions, varied from 11 million acre-feet (MAF) to 61 MAF between 1898 and 2015. The median runoff at Sioux City is 25 MAF—about 29 percent of this runoff enters above Fort Peck Dam, 42 percent enters between Fort Peck and Garrison Dams, 10 percent enters between Garrison and Oahe Dams, 3 percent enters between Oahe and Fort Randall Dams, 7 percent enters between Fort Randall and Gavins Point Dams, and 9 percent enters between Gavins Point and Sioux City. Any runoff below Gavins Point Dam is not influenced by the Missouri River Mainstem Reservoir System (System).



Source: USACE (http://www.nwd-mr.usace.army.mil/rcc/aop.html)

Figure 3-2. Annual Runoff in the Missouri River Upstream of Sioux City, Iowa (1898–2015)

Runoff in the lower river (from Sioux City to St. Louis) averages about 43 MAF (1967 through 2014), which accounts for 63 percent of the runoff in the basin. The most notable periods of drought were 1930 to 1941, 1954 to 1961, 1987 to 1992, and 2000 to 2007. The 1987 to 1992 drought ended with the “Great Flood of 1993” in the summer and fall of that year. The wet period following the drought in the 2000s included the record flood of 2011.

Climate, upstream tributary depletions, and construction of reservoirs on the mainstem and tributaries affect runoff upstream of Sioux City. Depletions and evaporation from large reservoirs reduce runoff from the basin. Depletions are likely to increase in the future, further reducing average annual basin runoff (USACE 2004a; refer to the report “Climate Change Assessment – Missouri River Basin” available on the MRRP website at www.moriverrecovery.org).

Groundwater and surface water evaporate in warm weather periods, primarily from April through October (USACE 2006a). The average annual evaporation rate in the reservoirs of the Missouri River basin is less than 2 feet in the western Rocky Mountains and more than 6 feet in the plains area of western Kansas. Evaporation from the mainstem reservoirs averages 3 feet annually.

The description of the affected environment includes the major USACE actions in the basin and the ongoing water resource processes associated with those actions.

3.2.1.2 USACE Missouri River Reservoir System and Hydrology

Reservoirs on the Upper River

The System consists of six dam and reservoir (lake) projects (Figure 1-2). USACE constructed, operates, and maintains these projects to serve congressionally authorized project purposes of flood control, navigation, irrigation, hydropower, water supply, water quality, recreation, and fish

and wildlife. The System has the capacity to store 72.4 million MAF of water, which makes it the largest reservoir system in North America. To achieve these multipurpose benefits, the System is operated in a hydrologically and electrically integrated manner.

- **Fort Peck Lake (Fort Peck Dam)**: The reservoir is 134 miles long and has a storage capacity of 18.5 MAF. Operating pool elevations range from a minimum of 2,160 feet to a maximum of 2,250 feet. Record pool elevations occurred in 1975 with 2,251.6 feet and on June 15, 2011, with 2,252.3 feet. Before 2011, the record flow release from Fort Peck Dam was 35,000 cubic feet per second (cfs) (1975); in mid-June 2011, a record flow of 65,900 cfs was released. The shoreline of the reservoir is 1,520 miles long (with pool elevation at base of flood control).
- **Lake Sakakawea (Garrison Dam)**: The reservoir is 178 miles long and has a storage capacity of 23.5 MAF. Record pool elevations occurred in 1975 with 1,854.8 feet and on July 1, 2011, with 1,854.6 feet. Before 2011, the record flow release from Garrison Dam was 65,000 cfs (1975); in mid-June 2011, a record flow of 150,600 cfs was released. The shoreline of the reservoir is 1,340 miles long.
- **Lake Oahe (Oahe Dam)**: The reservoir is 231 miles long and has a storage capacity of 23.0 MAF. Record pool elevations of 1,618.7 feet occurred in 1995 and 1996 and on June 26, 2011, with 1,619.7 feet. Before 2011, the record flow release from Oahe Dam was 59,000 cfs (1997); in mid-June 2011, a record flow of 160,300 cfs was released. The shoreline of the reservoir is 2,250 miles long.
- **Lake Sharpe (Big Bend Dam)**: The reservoir is 80 miles long and has a storage capacity of 1.8 MAF. A record pool elevation of 1,422.1 feet occurred in 1991. Before 2011, the record flow release from Big Bend Dam was 74,000 cfs (1997); in mid-June 2011, a record flow of 166,300 cfs was released. The shoreline of the reservoir is 200 miles long.
- **Lake Francis Case (Fort Randall Dam)**: The reservoir is 107 miles long and has a storage capacity of 5.3 MAF. Record pool elevations of 1,372.2 feet occurred in 1997 and on July 11, 2011, with 1,374.0 feet. Before 2011, the record flow release from Fort Randall Dam was 67,000 cfs (1997); in late July 2011, a record flow of 160,000 cfs was released. The shoreline of the reservoir is 540 miles long.
- **Lewis and Clark Lake (Gavins Point Dam)**: The reservoir is 25 miles long and has a storage capacity of 0.4 MAF. A record pool elevation of 1,209.7 feet occurred in 2010. Before 2011, the record flow release from Gavins Point Dam was 70,000 cfs (1997); in mid-June 2011, a record flow of 160,200 cfs was released. The shoreline of the reservoir is 90 miles long.

  Released water from the lowest dam in the System, Gavins Point Dam, flows down the lower river, which includes the Missouri River Bank Stabilization and Navigation Project (BSNP), from Sioux City, Iowa, to St. Louis, Missouri.

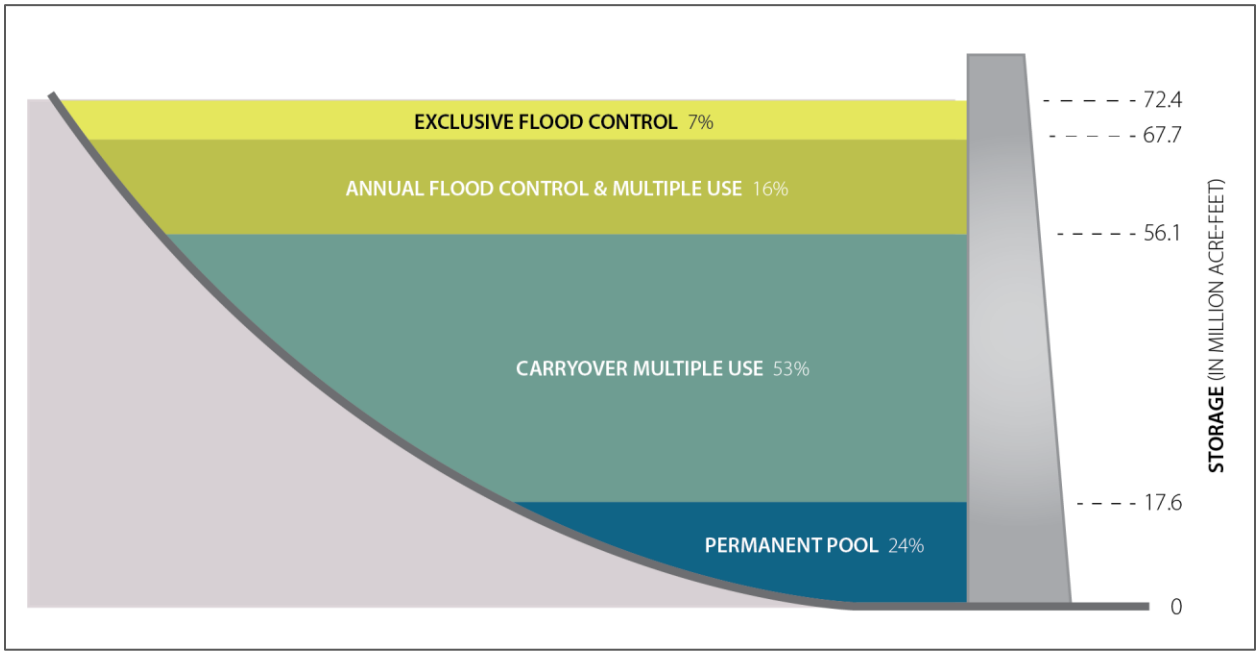
Reservoir Storage

The combined storage capacity of all six mainstem reservoirs is about three times the annual runoff in the basin above Sioux City, Iowa. The storage capacity of the System and each reservoir is divided into four storage zones for regulation purposes (Figure 3-3):

- **Permanent Pool**: Designed for sediment storage, minimum fisheries, and minimum hydropower heads.

- **Carryover Multiple**: Designed to serve all project purposes, although at reduced levels through a severe drought such as the drought in the 1930s.
- **Annual Flood Control and Multiple Use Zone**: This zone is the preferred operating zone. Ideally, the System storage is at the base of this zone at the start of the spring runoff season. Spring and summer runoff is captured in this zone reducing flood risk between and below the mainstem dams. The stored water is metered out through the remainder of the year to serve the other project purposes, returning the reservoirs to the base of this zone by the start of the next runoff season.
- **Exclusive Flood**: This zone is used only during extreme floods, and evacuation is initiated as soon as downstream conditions permit.

The total water volume in System storage gradually increased during the 1950s as the reservoirs filled and reached the base of the System's annual flood control zone for the first time in 1967. The reservoir filling period and subsequent System operation has dramatically altered stream flows within the basin.



Source: http://www.nwd-mr.usace.army.mil/rcc/reports/pdfs/rcc2015summary.pdf

Figure 3-3. Missouri River Mainstem System Storage Zones and Allocations

System Operation

The operation of the System is guided by the Missouri River Master Water Control Manual (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 typical reservoir operation cycle for flood control, hydropower, navigation, water supply, irrigation, recreation, water quality, and fish and wildlife is shown in Figure 3-4.

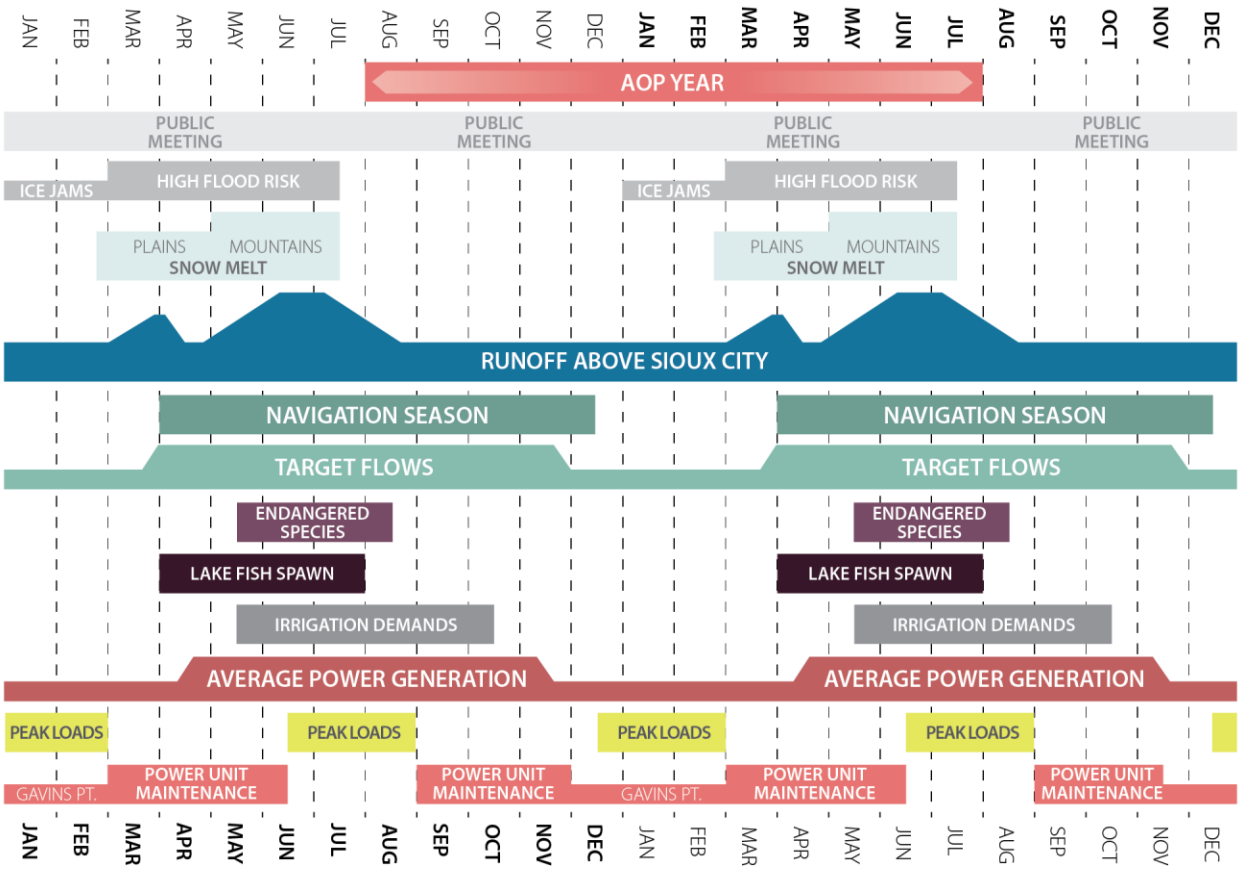


Figure 3-4. Typical System Operation Cycle

3.2.1.3 Bank Stabilization and Channelization Projects and River Channel Geometry

Historically, the channel geometry of the Missouri River and flows across the riverbed varied widely. The width of the main channel ranged from roughly 1,000 to 10,000 feet during normal flow periods and 25,000 to 35,000 feet during floods (Schneiders 1999), resulting in a wide floodplain. The channel geometry continuously changed as varying flows and sediment loads in the river resulted in frequent erosion, deposition, degradation (i.e., lowering of the channel bed), and aggradation (i.e., raising of the channel bed); the formation of sandbars, mudflats, chutes, pools, log jams, whirl pools, and backwaters; and the development of meanders and cut-off channels. The thalweg (i.e., primary flow channel) was narrow and highly variable in both location and depth. Most of these changes occurred during flood events.

Post-dam construction, the Missouri River is channelized in the lower river downstream of Ponca and unchannelized between Gavins Point Dam and Ponca and in inter-reservoir reaches upstream of Gavins Point Dam along the upper river (Table 3-2; Figure 3-5). The inter-reservoir reaches are bounded by a dam and degradation reach on the upstream end, and an aggradation reach near the reservoir delta headwaters on the downstream end. Stabilization projects in the upper river inter-reservoir reaches have been comparatively small. Flows and the capacity of the river channel have potential impacts such as flooding within each reach, as discussed further in Section 3.12, Flood Risk Management and Interior Drainage.

The river is also largely unchannelized in the 59-mile stretch below Gavins Point Dam down to Ponca, Nebraska (river mile [RM] 752); this reach is designated as a Missouri River National Recreational River. This reach is a meandering channel with many chutes, backwater marshes, sandbars, islands, and variable current velocities. Although this reach includes some bank stabilization structures, the river remains fairly wide. Bank erosion rates since the closure of Gavins Point Dam in 1956 have averaged 132 acres per year between Gavins Point and Ponca, compared to a pre-dam rate of 202 acres per year.

Table 3-2. Inter-Reservoir Reaches in Upper Missouri River

Inter-Reservoir Reach (at normal reservoir elevations)	**Distance** (river miles, approximate)	**Channel Capacity**[a] (kcfs, estimate)	**Largest City along the Reach**
Fort Peck Dam to Lake Sakakawea	204	35–40	Williston, ND
Garrison Dam to Bismarck	75	55–60	Bismarck, ND
Downstream of Bismarck to Lake Oahe	18	35–40	
Oahe Dam to Lake Sharpe	17	(not available)[d]	Pierre, SD
Big Bend Dam to Lake Francis Case	(There is no inter-reservoir reach.)		
Fort Randall Dam to Lewis and Clark Lake[b]	52	35–40	Springfield, SD
Gavins Point Dam to Rulo, NE[c] (Lower River Reach)	313	80 to 85	Omaha, NE

a The channel capacity estimate is based on an evaluation of hydraulic model results. The estimated channel capacity refers to the flow level at which significant water levels exceed bank elevations (may represent ponding water and not necessarily flow through connectivity). Values vary considerably within the reach and may change over time. Flow value is total flow at the specified location and includes both upstream reservoir releases and downstream inflows.

b Includes Fort Randall Dam to upstream of Niobrara River confluence (35 river miles), and upstream of Niobrara River confluence to headwaters of Lewis and Clark Lake (17 miles).

c This reach is not an “inter-reservoir reach” but it is a lower river reach that includes the somewhat natural condition, commonly referred to as the recreational river, for the first 60 river miles downstream of Gavins Point Dam (although significant degradation has occurred downstream of the dam). The reach also includes the upper 240 miles of the navigation channel from Sioux City to Rulo, NE.

d There is not a hydraulic model for this river reach. No channel capacity was estimated.

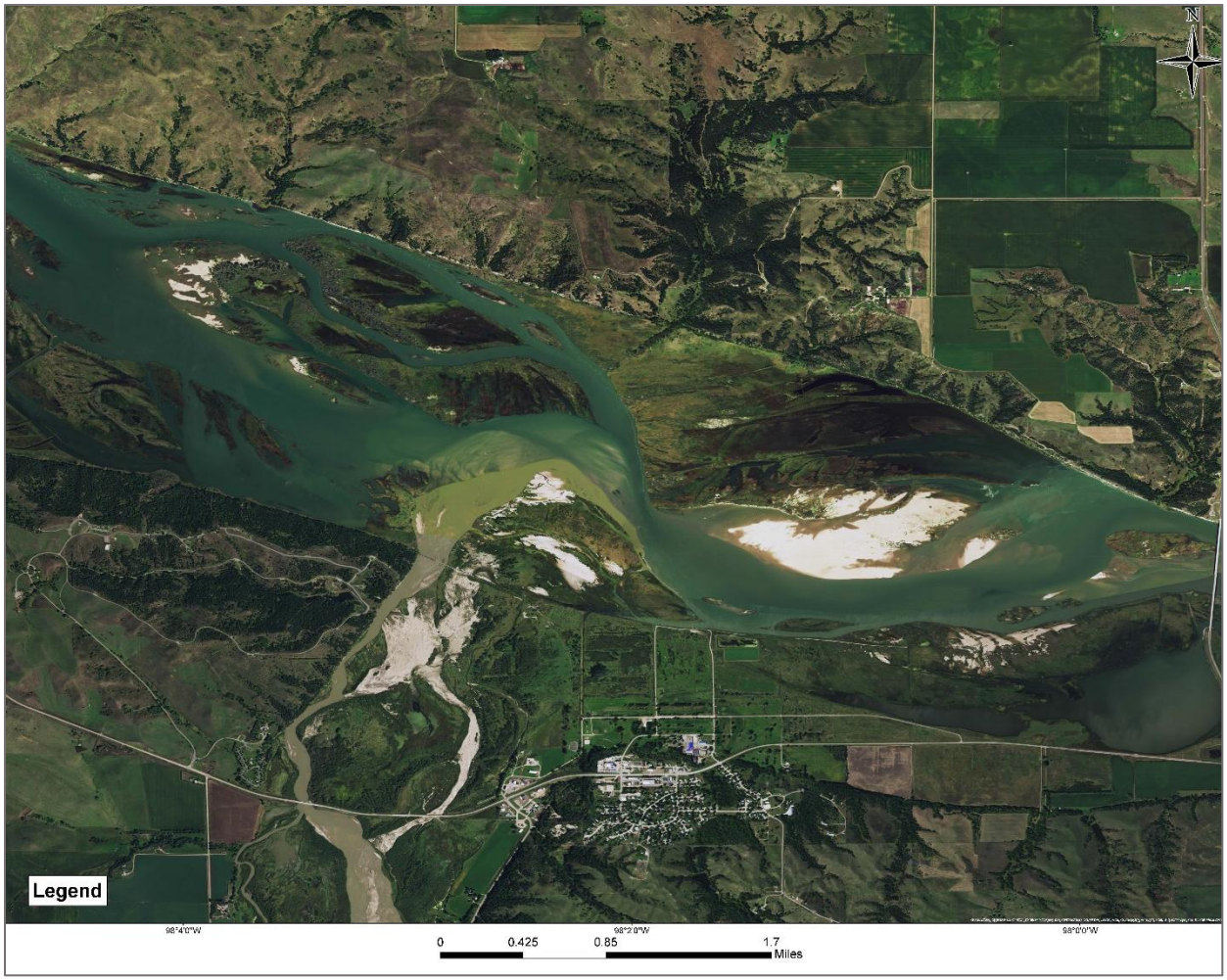


Figure 3-5. Unchannelized Missouri River near the Confluence with the Niobrara River, 17 River Miles Upstream of Lewis and Clark Lake

More extensive stabilization and channelization occurred in Kensler's Bend Reach between Ponca (RM 752) and above Sioux City (RM 735) through dikes and revetments (USACE 1961), and particularly in the navigable lower river between Sioux City (RM 735) to the mouth of the Missouri River (RM 0) to provide a continuous navigation channel without the use of locks and dams (Figure 3-6; Figure 3-7). Authorized channel dimensions are achieved through supplementary flow releases from Gavins Point Dam and occasional dredging and maintenance (USACE 2012). The BSNP is designed for a self-scouring channel that uses the controlled erosive forces of flowing water to provide channel widths and depths, while providing stability to the river location and features (see Section 1.4.3 for more details on the BSNP). These measures concentrated the flow in the lower river, resulting in increased flow velocities, degradation of the riverbed, and a reduction of the size of the floodplain. The typical channel geometry of a channelized river is trapezoidal with comparatively uniform water depths (Figure 3-8).

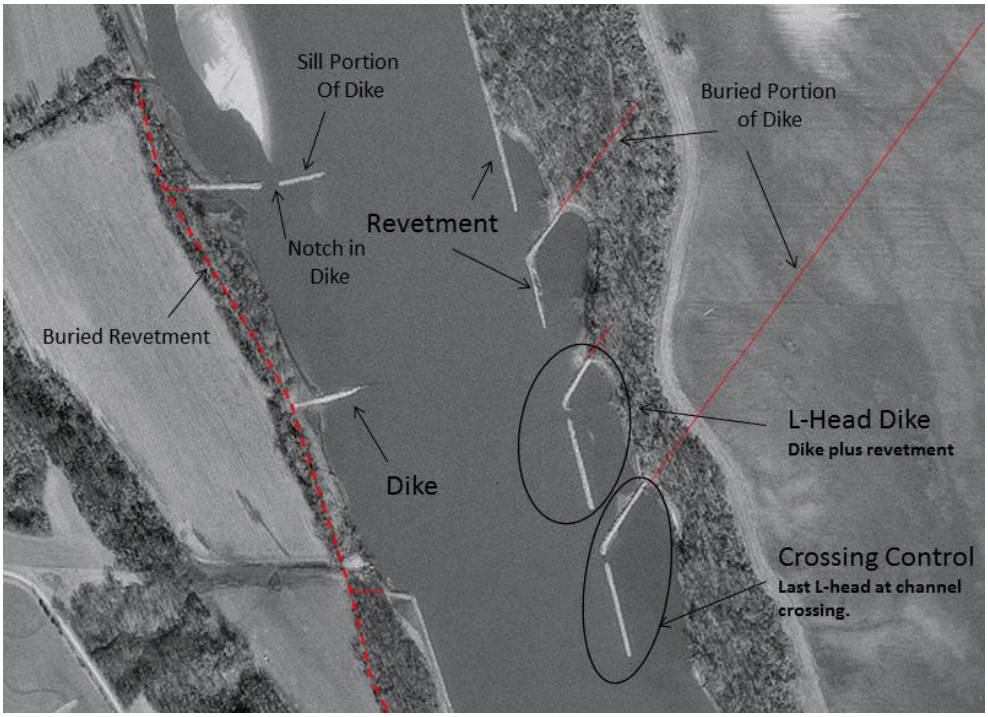


Figure 3-6. Typical Structures of the Bank Stabilization and Navigation Project in the Lower Missouri River

Figure 3-7. Channelized Missouri River near Little Sioux, Iowa (RM 672), Prior to Implementation of the Deer Island Top Width Widening Project (Looking Downstream)

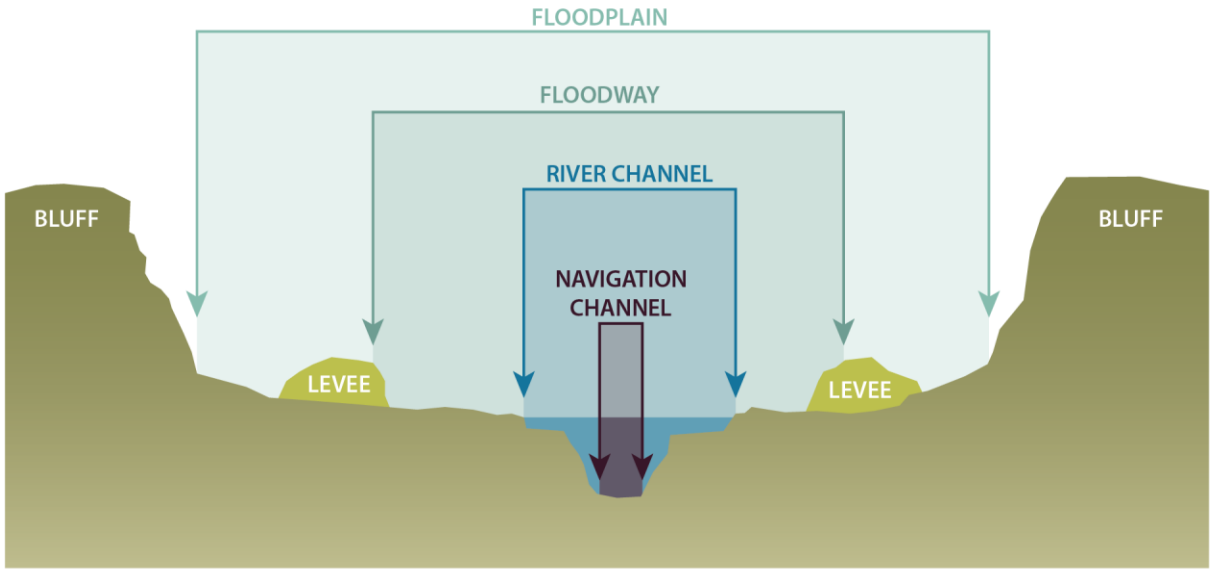


Figure 3-8. Common River Channel Geometry in Channelized River; Floodway Location with Respect to Levee and Channel Varies Significantly

3.2.1.4 Geomorphological Processes

The six mainstem reservoirs are located in the Great Plains portion of the Missouri River basin, where the slope is generally gentle and the bedrock is generally composed of shales and sandstones. The land surface consists of a mixture of glacial material, river deposits, and wind-blown sediment. Soils consist of a mixture of clay, silt, sand, and gravel. As a result of these unconsolidated materials, shorelines and the bottoms of the reservoirs and river reaches are highly erodible.

Sediment is an integral part of geomorphological processes and important for building and sustaining habitats in a river system. The amount, size, and type of sediments in the river system affect the kinds of plants and animals occupying the various river habitats. Although sediment is trapped in the upper river by the reservoirs, the Missouri River continues to be a large source of sediment to the Mississippi River.

Sediment is transported by the river either as suspended sediment in the water column or as bedload on the channel floor. The suspended sediment load in the river is directly related to the turbidity of the water, which affects the types and densities of aquatic organisms. Bedload consists of coarser-grained sediment particles (sand and gravel), which can either be suspended for short periods of time or are rolling along the riverbed, depending on the flow velocity.

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.

Degradation and Bank Erosion

Sediments carried by the upper Missouri River and its tributaries are deposited in the upper ends of the reservoirs. As a result, the river channel downstream of the dams deepens (degrades) as sediment that erodes from the channel floor is not replenished with sediment from upstream sources. Aside from degradation, the riverbed experiences progressive armoring. Armoring is the gradual loss of finer sediment particles and the buildup of progressively larger sediment grain sizes, such as gravel and cobbles. The channel bed at the mouths of tributaries entering a degraded reach of the mainstem Missouri River may also degrade (i.e., head cutting). In some stretches of the river, the degradation rates have decreased substantially since reservoir construction, while in other stretches degradation continues to shape the river as it seeks its dynamic equilibrium.

Degradation and head cutting have led to increased erosion, aquatic habitat degradation, reduced fish access up some of the affected tributaries, and increased public expenditures to maintain infrastructure. Unprotected riverbanks along the Missouri River are also being eroded, but at a reduced rate in the absence of historic flood flows. Without overbank and sediment-laden flows, new high banks are not formed in the reaches immediately below the dams. Fewer flood flows have also led to less erosion of sandbars.

- **Fort Peck Dam to Lake Sakakawea**: Although most of the bed degradation below Fort Peck Dam occurred before 1966, some degradation continues in the upper and center portions of the 204-mile reach, causing some streambank erosion (USACE 2004a). Degradation below the dam (RM 1772) occurs at differing degrees to about RM 1650. Below RM 1650, no substantial degradation has occurred since 1966. The width of the river channel has not increased much as a result of streambank erosion, except in isolated stretches between RM 1746 and RM 1612. Streambank erosion rates for the entire reach were about 97 acres per year from 1975 to 1983.
- **Garrison Dam to Lake Oahe**: Degradation of the riverbed below Garrison Dam (RM 1390) occurs primarily in the upper 35 miles of the 87-mile reach, although degradation rates began to level off around 1983 (USACE 2004a; USACE 2012a). The riverbed below the dam degraded about 5 feet between 1950 and 1975, but further degradation is unlikely to occur, except during high-flow periods. The riverbed 25 to 50 miles below the dam continues to degrade, but the rate of degradation also decreased after 1975. Since 1960, erosion of the streambed in this area has lowered the riverbed by approximately 4 feet. The channel widths for the first 20 miles below Garrison Dam have remained fairly constant, with the exception of the mouth of the Knife River (RM 1378) where sediment deposits have been decreasing the Missouri River channel width. Downstream of the Knife River confluence, the Missouri River channel is widening. Streambank erosion rates were 48 acres per year from 1978 to 1982 for the 93-mile reach.
- **Oahe Dam to Lake Sharpe**: This reach is relatively stable because of the short distance of open water and implementation of protective measures.
- **Fort Randall Dam to Lewis and Clark Lake**: From 1953 to 1997, the riverbed downstream of the dam degraded from RM 880 to RM 860 by up to 6 feet and the channel widened, although the rate of erosion decreased over this period (USACE 2004a). Streambank erosion since closure of the dam in 1953 has averaged about 40 acres per year.
- **Missouri River from Gavins Point Dam to Ponca, Nebraska**: Since 1955, erosion of the riverbed and streambank has been gradual (USACE 2004a). Degradation has been

highest (about 10 feet) in the reach immediately below the dam, although riverbed erosion has diminished since 1980. Post-dam streambank erosion rates between 1956 and 2011 have averaged 120 acres per year, but have declined somewhat since 1975. Streambank erosion rates are higher during high flow events.

- **Missouri River from Ponca to St. Louis**: Within this reach, degradation of the river channel continues down to the confluence with the Platte River. Sediment supplied by the Platte River adds to stabilization of the river channel, although channel degradation still occurs in some reaches of the river between the Platte River confluence and the mouth of the Missouri River in St. Louis. This includes a 100 to 200 miles reach in the greater vicinity of Kansas City. Degradation may also occur over the short term as a result of specific hydrologic conditions in the river. Streambank erosion rates in the lower Missouri River are lower than in the upper river because of extensive bank stabilization measures. Within the lower Missouri River, the primary geomorphic influence is the navigation channel which contains, in comparison to the historic river, fewer sandbars and side channels. Floodplain levees along much of the lower river have reduced overbank flooding, thereby decreasing water flows to old sloughs and chutes.

Reservoir Sediment Deposition and Aggradation

The mainstem reservoirs are catchment basins for the sediment load carried by the Missouri River. Approximately 100,000 acre-feet of sediment enter these reservoirs annually. Sediment is also supplied by intermittent erosion of the riverbanks and channel bars during flood events, as well as by channel bed erosion in degrading river and tributary segments further upstream. As of 2012, sedimentation reduced the originally available total storage capacity in the reservoirs by approximately 5 percent. Sediment is deposited slightly below the prevailing reservoir water level. Most of the loss to the capacity of the permanent pool zones occurred during the filling period before 1967 (see Figure 3-3). Since then, the loss has been occurring primarily in the carryover multiple use zone.

Sedimentation has resulted in large deltas at the head of the reservoirs. Although these deltas continue to grow, the useful life of the reservoirs is at least several hundred years because of their large storage volume. The growing deltas have posed problems at many of the reservoirs. Sediment accumulation within the channel (aggradation) has resulted in flooding and high groundwater tables at the head of Lake Sakakawea, Lake Oahe, and Lewis and Clark Lake. Higher channel beds also result in lateral shifts of the thalweg, leading to bank erosion.

The growing deltas have blocked boat ramps and cut off some reservoir arms. Boat ramps and fish spawning and rearing habitat are often concentrated in reservoir arms. Changes in reservoir elevations also lead to changes in sediment deposition patterns within the reservoirs. When reservoir elevations are lower, sediment is eroded from the deltas and is deposited farther downstream in the reservoir. With subsequent higher storage, sediment is again deposited farther upstream nearer to the head of the reservoir.

Aggradation in the Missouri River may also occur at the confluence with larger tributaries (such as the Niobrara River) when flow in the Missouri River is insufficiently high to remove the accumulated sediment of the tributary deltas.

- **Fort Peck Dam to Lake Sakakawea**: Aggradation of the riverbed and in the Lake Sakakawea delta has caused a backwater impact between the reservoir and the mouth

of the Yellowstone River that has resulted in flooding. The USACE built levees in this reach to protect the City of Williston and nearby agricultural lands.

- **Garrison Dam to Lake Oahe**: At the time Garrison Dam was constructed, the open water channel capacity at the City of Bismarck, North Dakota, was approximately 90,000 cfs for a stage of 13 feet; however, aggradation decreased the channel capacity to approximately 50,000 cfs for the same stage by 1997 after 42 years of reservoir operation (USACE 2006a). This trend was temporarily decreased in 2011 when high flows scoured out the channel.
- **Fort Randall Dam to Lewis and Clark Lake**: A relatively large loss of channel capacity has occurred in the downstream Fort Randall river reach, in part because of the sediments from the Niobrara River deposited at its mouth (Figure 3-5), and because of aggradation in the Missouri River (USACE 2006a). This topic is further discussed in Section 3.12, Flood Risk Management and Interior Drainage.
- **Gavins Point Dam to St. Louis**. As stated above, sediment supplied by the Platte River and other tributaries adds to stabilization of the river channel. Aggradation of the river channel may occur locally, as well as on a short-term basis as a result of specific hydrologic conditions. Aggradation has also occurred locally on the floodplain, although specific causes and the persistence of aggraded sections are not well understood.

Reservoir Shoreline Erosion

The uppermost layer near the top of the reservoirs tends to be highly erodible silty, wind-blown soils of the plains, particularly along Lakes Sakakawea and Oahe. In addition, wave and ice actions lead to accelerated erosion in the form of slumping cut-banks. The cut-banks are continually slumping into the reservoirs at rates as high as 20 feet per year. At such rates, protective vegetation does not have sufficient opportunity to take root and protect the cut-banks from further erosion.

Bank erosion rates are affected by seasonal and annual water-level fluctuations as a result of reservoir regulation. Generally, the erosion rates are much higher at higher reservoir elevations. However, some shoreline segments with more consolidated and coarser-grained material experience lower erosion rates. For example, high gravel or cobble content in the soil results in armoring at the toe of the cut banks and reduced erosion rates. Lower water elevation exposes silt deposits; subsequent drying causes hardened soils that do not revegetate. Lower water elevations also allow waves to erode shorelines and terraces that were previously protected by higher reservoir elevations. Erosion during lower reservoir elevations may further undermine cut-banks and possibly lead to larger slides or bank cave-ins (USACE 2004a).

Long-term shoreline erosion rates in most areas have decreased substantially since dam closures. However, erosion of the reservoir shorelines is expected to continue to some extent throughout the life of the projects. The majority of eroded material usually remains immediately offshore, forming a flat beach slope. As a result, the perimeters of the reservoirs are slowly becoming shallower and wider. In some cases, sediment moves along shore in the direction of the prevailing wind or current and collects in deeper channels of tributary arms. Some reservoir arms are filling and being cut off by these reservoir sediments and collapsing cut-banks. Erosion of shorelines adversely affects recreation facilities and numerous historic and cultural properties. The thousands of miles of shorelines in the reservoirs remain largely unprotected because the costs of protection are high.

Ice Dynamics

River ice dynamics refer to the pattern of ice formation, breakup, and movement on the Missouri River. Aspects of ice dynamics, such as the time and duration of ice formation and the location and size of ice cover, play a role in physical and biological processes. Moving ice sheets can scour riverbanks and shallow parts of the channel and disturb shoreline vegetation. When ice forms on the river during extreme low-flow conditions, it can limit oxygen supply to the covered waters. Ice jams interfere with river flows and can cause temporary, localized flooding (upstream) and flow depletion (downstream), and their break-up can cause temporary, localized high-flow events. Ice jams can also affect water supply. Ice dynamics within reservoirs can result in reservoir bank damage and accelerated erosion rates. Altering reservoir levels, combined with delta location, are factors in the location and severity of spring ice jams and breakup processes. Alteration of river ice dynamics therefore can disturb a river ecosystem.

The USACE operates the mainstem reservoir releases in winter to minimize problems with ice; however, sometimes problems cannot be averted. The potential for ice cover and resulting problems at any given location along the Missouri River is a function of cold weather intensity and flow discharge at particular locations. River ice is more prevalent in the upper river, but it is also a factor in the lower river. Mainstem dam releases are adjusted to consider ice conditions; minimum releases from Gavins Point Dam are 3,000 cfs higher during the winter (December through February) than during any non-navigation periods before and after to adequately serve water supply intakes downstream.

3.2.1.5 Groundwater

Groundwater elevation is a key factor in the composition and spatial distribution of vegetation communities and their associated fauna across the floodplain. Groundwater in the alluvial sediments of the floodplain, also referred to as the alluvial aquifer, supplies water to floodplain plant and wetland communities (e.g., cottonwood floodplain forests), particularly during dry, late summer periods. The elevations of the groundwater table in the alluvial aquifer vary in response to factors such as river stage, precipitation, and evapotranspiration. These elevations are also affected by human activities such as groundwater pumping, intentional drainage of floodplain soils, and alterations to the shape and hydrology of the mainstem and side channels of the river.

- **Inter-Reservoir Reaches in the Upper River**: Within the degradation reach downstream of each dam, lower riverbed elevation lowers the local groundwater table, which affects vegetation and side channels. Within the reservoir delta deposition zones (aggradation areas), groundwater levels are generally rising and can affect vegetation, including crop yields in farmlands around the delta. Areas in the vicinity of the reservoir pool experience fluctuating groundwater levels because the reservoir elevation typically varies seasonally.
- **Lower River**: Groundwater tables generally rise and fall with the stage in the river. Many floodplain wetlands and riparian communities are sensitive even to small changes in groundwater table elevations. As a consequence of navigation channel construction and the formation of accretion lands from that process, combined with bed degradation, levee construction, and other local water resource projects, drainage has improved on the floodplain and accreted lands have been developed for agricultural purposes. Along the channelized river, relatively few oxbow lakes and isolated backwaters remain (compared to the historic channel prior to navigation channel construction). These areas are passively maintained by groundwater seepage or surface inflow, or actively

maintained by pumping of groundwater or surface water. Although still important resources, the separation of these isolated oxbows and backwaters from the river channel has reduced their functional value as habitat.

3.2.2 Environmental Consequences

This section assesses the impacts of the alternatives on the hydrology, geomorphology, and infrastructure in the river, as well as groundwater along the river.

3.2.2.1 Impacts Assessment Methodology

Hydrology

The impact assessment was in part based on flow analysis for the POR using HEC-ResSim and HEC-RAS models, as described in Section 3.1. The impacts of releases in the river and reservoirs were analyzed using the statistical 90th, 50th, and 10th percentiles of the 82-year POR.[1] Specifically, a percentile is a statistical measure indicating the value below which a given percentage of observations in a group of observations falls. For example, the 90th percentile of a reservoir elevation reflects the elevation below which 90 percent of the elevations may be found; only 10 percent of the elevations would be higher. Thus, the 90th percentile may be used as a proxy for “wet period” conditions. A “period” could be a year or several years long, affecting storage and flow conditions. Similarly, the 10th percentile is the reservoir elevation below which 10 percent of the elevations may be found; 90 percent of the elevations would be higher. Thus, the 10th percentile may be used as a proxy for “dry period” conditions. Finally, the 50th percentile is the reservoir elevation that may be used as a proxy for “average” conditions, where 50 percent of the elevations are higher and 50 percent of the elevations are lower. Similar definitions also apply to percentiles used for flow and stage in the river.

Releases were also assessed for individual simulated years from the POR to illustrate potential impacts on reservoirs and river reaches for specific action alternatives. These years were selected because they reflect when a release was simulated due to the “rules” governing the release within an alternative. Whether and to what extent a release was simulated for a specific year was dependent on these “rules” and in many years of the POR no release would occur. For example, the extent or magnitude of the releases are dependent on system storage levels and are reduced or curtailed if storage levels fall below certain levels specified in the “rules” for that alternative. Therefore, river flow and reservoir elevations resulting from releases change depending on hydrologic conditions in the larger Missouri River watershed. Specifically, the years used for illustration purposes reflect when the full extent of a release would occur and consist of the following (all examples were compared to the No Action alternative):

- 1966: March and May spawning cue releases and low summer flow under Alternative 2 (USFWS 2003 Biological Opinion (BiOp) Projected Actions)
- 1963: No spawning cue releases under Alternative 3 (Mechanical Construction Only)
- 1974 and 1975: Spring and fall releases simulated for 1974 under Alternatives 4 and 5 (Habitat-Forming Flow Releases), respectively. Although no releases would have

[1] The analysis is limited to an 82-year POR; consequently, the number of years with flow conditions that would trigger releases under the various action alternatives is limited and statistically small. The limited data set necessitates monitoring of impacts under any implemented action alternative and adaptive management.

occurred under these two alternatives in 1975, this year was also analyzed to demonstrate the residual impact on the hydrology from the releases that occurred in 1974.

- 1975: Releases under Alternative 6 (Pallid Sturgeon Spawning Cue)

Impacts are assessed for flow (measured in cfs) and stage (measured in feet) for various locations. Flow is relevant because it affects erosion and deposition rates in the river. Stage allows for an assessment of impacts to resources and uses, which are driven by water surface elevations.

Geomorphology

The primary geomorphological issues associated with the proposed alternatives consist of degradation and streambank erosion, reservoir sediment deposition and aggradation, shoreline erosion in reservoirs, ice dynamics, and channel reconfiguration (lower river).

Each geomorphological issue was assessed by reviewing existing documents, data, and other relevant information. These sources included an analysis of emergent sandbar habitat by the USACE (2014a). The assessment considered temporary impacts from individual releases under the various alternatives and long-term impacts on a time scale of decades:

- Temporary impacts pertain to impacts that exceed conditions under the No Action alternative and may occur locally or over larger distances for the period of an individual release.
- Long-term impacts pertain to impacts that, on balance, alter geomorphological conditions in the river and reservoirs beyond what would be expected under the No Action alternative. The analysis considers the fact that the total volume of water passing through the river system remains unchanged, although the action alternatives would alter the timing and flow rates of the releases. The analysis also considers that peak flow events result in comparatively higher sediment erosion and transport rates than regular or especially low flows. Therefore, high flow releases can cause additional erosion in the river and along streambanks, and subsequent redeposition of mobilized sediment in aggrading reaches.

Riverine Infrastructure

Impacts on riverine infrastructure were assessed qualitatively because impacts are largely flow driven. The analysis considered that increased flows could result in erosion and wear and tear of structures.

Groundwater

Impacts on groundwater were also assessed qualitatively because they are largely a function of stage in the river. In general, prolonged periods of higher stages would result in higher groundwater elevations; lower stages would result in lower groundwater elevations.

The No Action Alternative is considered the baseline against which the other alternatives are measured. Under the No Action Alternative, the MRRP would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, the No Action

Alternative does 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.

3.2.2.2 Summary of Environmental Consequences

Table 3-3 summarizes the impacts of each alternative relative to river infrastructure and hydrologic processes. Over the long term and considering the hydrologic variability in the POR, the action alternatives would be expected to have small to negligible, adverse impacts on the hydrology, geomorphology, river infrastructure, and groundwater relative to the No Action alternative. However, impacts could be large temporally and locally.

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.

Table 3-3. Environmental Consequences Relative to River Infrastructure and Hydrologic Processes

Alternative	Impacts on River Infrastructure and Hydrologic Processes*
Management Actions Common to All Alternatives	• Predator management, vegetation management on ESH, and human restrictions measures for terns and plovers would not affect the hydrology, geomorphology, river infrastructure, and groundwater.
Alternative 1 (No Action)	• Hydrologic conditions include the wide range of natural flows and system operations by the USACE in response to these flows. • Continued degradation of river channel and bank erosion in the reaches below dams as a result of a lack of resupply of sediment (because it is trapped behind the dams). Continued aggradation of the riverbed upstream of reservoirs as a result of redeposition of eroded sediment from the degrading part of the mainstem and its banks and the influx of sediment from tributaries along the reach. There is also streambank erosion in aggrading river reaches. • Continued erosion of reservoir shorelines. • Changing flows affect river infrastructure and groundwater levels. • Small to negligible impacts from mechanical ESH construction (upper river).
Alternative 2	• Overall, small, temporary, and long-term impacts on the river system from spawning cue releases, including changes in reservoir elevations and shoreline erosion in the upper three reservoirs, and degradation and aggradation in the inter-reservoir reaches along the upper river and the Gavins Point Dam to Ponca reach. Locally, impacts could be large. • Small to negligible, temporary, and long-term impacts from releases in the lower river downstream of Ponca because geomorphological conditions are dominated by large, natural meteorological variations and because flow releases in the lower river would be increasingly attenuated with distance from Gavins Point Dam. Temporary, localized aggradation in the lower river from low summer flows that could require localized dredging. • May cause localized impacts on riverine infrastructure and groundwater elevations. • Small to potentially large impacts from ESH construction (upper river).
Alternative 3	• Negligible to no impacts on the overall hydrology and geomorphology in the river compared to the No Action alternative because absence of the existing spawning cue would have negligible changes to river flow and reservoir elevations. • Small to negligible impacts from mechanical ESH construction (upper river).

Alternative	Impacts on River Infrastructure and Hydrologic Processes*
Alternative 4	• Overall, small, temporary, and long-term impacts on the river system from spring ESH creation releases, including changes in reservoir elevations and shoreline erosion in the upper three reservoirs, and degradation and aggradation in the inter-reservoir reaches along the upper river and the Gavins Point Dam to Ponca reach. Locally, impacts could be large. • Small to negligible impacts in the lower river downstream of the Platte River confluence, because of gradual attenuation of flow releases with distance from Gavins Point Dam as a result of inflows from tributaries. • May have localized impacts on riverine infrastructure and groundwater elevations. • Small to negligible impacts from mechanical ESH construction (upper river).
Alternative 5	• Same impacts as described under Alternative 4, except during the fall instead of the spring.
Alternative 6	• Similar small to negligible (depending on the reach), temporary, and long-term impacts on the river and reservoirs as described under Alternative 4, although the extent of impacts from the spawning cue releases under Alternative 6 would be smaller because of the smaller volume of water released from the System.

* Impacts listed for Action Alternatives 2 to 6 are compared to the No Action Alternative (Alternative 1).

3.2.2.3 Impacts on Hydrology from the Alternatives

The frequency of when releases would occur under the various alternatives based on the POR is listed in Table 3-4. Spawning cue releases with both March and May pulses would occur 20 percent, 12 percent, and 13 percent of the time under Alternatives 1, 2, and 6, respectively. Deliberate spring flow releases under Alternative 4 would occur 12 percent of the time, while deliberate fall flow releases under Alternative 5 would occur 8 percent of the time. Flow release levels under Alternatives 4 and 5 would be achieved “naturally” during normal project operations in 8 years (10 percent of the time) during spring and fall, based on the 82-year record.

Impacts under wet, average, and dry period conditions (90th, 50th, and 10th percentile, respectively) are presented together for the six alternatives to demonstrate similarities and differences. However, hydrologic conditions during individual years could result in specific changes under individual alternatives. For example, during extreme droughts (i.e., in the 1930s) and peak flow events (i.e., the spring and summer of 2011), rules would prevent flow releases under Alternatives 1, 2, 4, 5, and 6 from contributing to the effects of these extreme conditions. Graphics pertaining to this discussion are provided in Appendix D: Hydrologic Period of Record Analysis of Alternatives.

Table 3-4. Summary of Releases Simulated under the Six Alternatives over the Period of Record

		Frequency during 82-year POR (1931–2012)			
		No Occurrence[a]	Partial Completion[b]	Full Completion/Duration[c]	
Alternative	Month	No. of Years	No. of Years	No. of Years	Percent
1 – No Action	March	48	4	30	37
	May	53	8	21	26
	Both months			**16**	**20**
2 – USFWS 2003 BiOp Projected Actions	March	40	24	18	22
	May	42	25	15	18
	Both months			**10**	**12**

Alternative	Month	Frequency during 82-year POR (1931–2012)			
		No Occurrence[a]	Partial Completion[b]	Full Completion/Duration[c]	
		No. of Years	No. of Years	No. of Years	Percent
3 – Mechanical Construction Only		Not applicable, no flow management action included			
4 – Spring Habitat-Forming Flow Release		67	5	**10**[d]	**12**
5 – Fall Habitat-Forming Flow Release		73	2	**7**[d]	**8**
6 – Pallid Sturgeon Spawning Cue	March	39	26	17	21
	May	65	6	11	13
	Both months			**11**	**13**

Notes:

a No Occurrence: Operating "rules" would not have triggered a release.

b Partial Completion: Releases would have occurred but not at the full planned volume or duration. There are 44 years that contain a partial release in either March or May.

c Full Completion/Duration: Releases would have occurred for the full planned volume and duration.

d Shown values for spring (Alternative 4) and fall (Alternative 5) are deliberate releases. These values do not include eight events for each alternative when targeted flow release levels would have been achieved "naturally" during normal operations.

Hydrology in Reservoirs in Upper River: The water surface elevations for the upper four reservoirs for the 90th, 50th, and 10th percentile conditions based on the POR are shown in Figure D-2 to Figure D-5 in Appendix D. Overall, the elevations in the reservoirs are dominated naturally by precipitation (i.e., rainfall and snowmelt) in the watershed of the upper river (aside from System operation by the USACE). Although the six alternatives could affect the elevations in the reservoirs to varying extent throughout the year, these variations are small compared to natural variations.

- **Fort Peck Lake**: The reservoir elevations simulated for the six alternatives for the POR would generally be within a few feet of each other, both for the three percentile conditions (90th, 50th, and 10th) and for individual years. The largest deviations were simulated for hydrologic conditions in 1931 to 1933 because of the drought in 1930 and 1931, with elevations under Alternative 4 of up to 8 feet lower than elevations under other alternatives.
- **Lake Sakakawea**: The reservoir elevations simulated for the six alternatives for the POR would generally be within a few feet from each other for the three percentile conditions, particularly for average and wet period conditions (50th and 90th percentiles, respectively). For dry period conditions (10th percentile), the elevations under Alternative 4 would be up to 5 feet lower throughout the year than under other alternatives. On a year-by-year comparison, elevations under Alternatives 2, 4, and 5 would occasionally be up to 10 feet lower than under Alternatives 1 and 6.
- **Lake Oahe**: Compared to Lake Sakakawea, reservoir elevations in Lake Oahe simulated for the six alternatives for the POR would be slightly more variable for all conditions. During dry period conditions, elevations under Alternatives 4 and 6 would be up to 7 and 4 feet (respectively) lower than under Alternative 1 throughout the year. The

largest deviations were simulated for hydrologic conditions in 1934 and 1935 (due to the drought in 1934) with elevations under Alternative 4 being up to 12 feet lower than elevations under Alternative 1. Such single-year differences could last several years while the upper reservoirs in the System are refilling.

- **Lake Francis Case**: During average and dry periods (50th and 10th percentiles), all six alternatives would result in elevations of 1,355 feet from April to September. Drawdown during the fall to elevation 1,337.5 feet would occur more rapidly during dry periods than during average periods due to the shortened navigation season; however, elevation changes in the fall would be similar for all six alternatives for both types of periods. During wet periods (90th percentile), elevations in the reservoir would exceed the 1,355-foot target from April to September, reaching approximately 1,360 feet for most alternatives. The exception would be Alternative 2 where 90th percentile elevations could reach 1,365 feet in early summer. Comparing elevations for hydrologic conditions of individual years throughout the POR indicates that this similarity in elevations for the six alternatives would apply for almost all flow conditions.

Hydrology in Inter-Reservoir Reaches of Upper River: The impact of the six alternatives simulated for hydrologic conditions of the POR were also simulated for the inter-reservoir reaches in the upper river.

- **Fort Peck Dam to Lake Sakakawea**: The action alternatives would have negligible impacts on the stage in the Missouri River at Culbertson, Montana, located upstream of the confluence between the Missouri and Yellowstone Rivers, for all conditions (90th, 50th and 10th percentiles). For individual years, only occasional small changes in stage would occur, particularly under Alternative 4.
- **Garrison Dam to Lake Oahe**: The action alternatives would have small, long-term impacts on the stage in the Missouri River at Bismarck for average and dry period conditions (50th and 10th percentiles, respectively). For the POR, the simulated stage would generally be within 0.5 foot for the alternatives throughout the year (Figure D-6 in Appendix D). For wet period conditions (90th percentile), the stage under all six alternatives would generally vary within 1 foot of each other throughout the year with the exception of the periods for the spring flow release (Alternative 4) and the fall flow release (Alternative 5). The spring flow release would affect the stage from April into May, while the fall flow release would affect the flow from October 15 into the second half of November. Both flow releases would raise the stage of the river to 10 feet, approximately 0.5 foot higher than the stage during the summer under wet period (90th percentile) conditions. The stage during both flow releases (Alternatives 4 and 5) would be approximately 3 to 4 feet higher than during wet period conditions for the other alternatives.

  Flows in the river at Bismarck would reflect a similar pattern as shown by the stages. The highest flows occur in spring and summer (Figure D-7 in Appendix D). Peak flows occurred in June 2011 with approximately 160,000 cfs (Figure D-8 in Appendix D), which was three times larger than the 90th percentile flow in the summer and seven times larger than the 50th percentile flow. Alternatives 2 through 6 would not affect the stage and river flow during peak events such as the event experienced in the summer of 2011.

  However, local, temporary, and long-term impacts on the river stage from flow releases under Alternatives 2, 4, 5, and 6 could occur as a result of degradation of the riverbed in the upper part of the reach and aggradation in the Missouri River upstream of Lake Oahe, as described in more detail in the following sections for individual alternatives.

- **Oahe Dam to Lake Sharpe**: The hydrology in this reach would be relatively stable because of the short distance of open water and the fairly stable elevation maintained in Lake Sharpe.
- **Fort Randall Dam to Lewis and Clark Lake**: The action alternatives would have small, long-term impacts on the stage in the Missouri River. However, locally large impacts on the river stage from flow releases under Alternatives 2, 4, 5, and 6 could occur for extended time periods because of aggradation in the Missouri River from deposits by the Niobrara River.

Hydrology in the Lower River: Locations in the lower river reviewed for flows and stages include Gavins Point Dam, Sioux City, Omaha, Nebraska City, and Kansas City (Figures D-9 to D-17 in Appendix D). The flow in the Missouri River at Gavins Point Dam simulated for the POR would generally be similar for each of the six alternatives throughout the year for average and dry period conditions (50th and 10th percentiles, respectively). The exception would be spring flow releases under Alternative 2, which would increase the average period flows by approximately 10,000 cfs compared to other alternatives during parts of May. Overall, average period flows at Gavins Point Dam would range between approximately 25,000 and 35,000 cfs from spring through fall. Flows during wet period (90th percentile) conditions would be more variable and would include the occasional spring and fall flow releases (Alternatives 4 and 5, respectively) and the spawning cue releases under Alternative 6. This pattern would largely remain intact at Sioux City and Omaha, although release peaks would start broadening with distance from Gavins Point Dam. At Nebraska City, these peaks would broaden and be attenuated substantially under wet period conditions (90th percentile) from the inflow of the Platte River. Further broadening would occur at Kansas City with release peaks no longer included in the wet period (90th percentile) flows. The effects on stage in the river would be similar at the four cities.

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

Existing hydrologic conditions would continue in the river. These conditions would include the wide range of natural flows and system operations by USACE in response to these flows.

Hydrologic conditions in the watershed would be suitable for complete March and May spawning cue releases 20 percent of the time (i.e., on average every fifth year) (Table 3-4); see Section 2.8.2 for specifics of these releases. However, these releases would be small compared to the natural variability in flows and would result in negligible impacts on the elevations in the reservoirs and stage and flow in the river.

The construction of ESH in the upper river and channel reconfiguration projects in the lower river would continue to be conducted in a manner that would maintain hydrologic conditions without adversely affecting the congressionally authorized project purposes of flood control, navigation, irrigation, hydropower, water supply, water quality, recreation, and fish and wildlife.

Conclusion

Hydrologic conditions under Alternative 1 would include the wide range of natural flows and system operations by USACE in response to these flows. Spawning cue releases would be small compared to the natural variability in flows and would result in negligible impacts on elevations in the reservoirs and stage in flow in the river. No effects would occur to hydrologic

conditions from habitat construction. Impacts to hydrology are not anticipated to be significant under Alternative 1.

Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

When conditions and rules allow, pallid sturgeon spring flow releases under Alternative 2 would consist of two pulses of water released in spring from Gavins Point Dam—one pulse in March and a second pulse in May. If both pulses meet their flow design specifications, a low summer flow would be initiated. For example, rules for Alternative 2 would allow for these releases to be initiated for hydrologic conditions simulated for 1966 (Figure 3-9). The modeling results for this year are discussed to provide a sense of the effects from these releases. Because the low summer flow operation under Alternative 2 would typically conserve more water relative to the No Action alternative, higher flows may continue later in the fall and early winter in some years.

These releases would predominantly be carried out by altering releases from Lake Oahe. As a result, elevations in Lake Oahe would decrease in the spring and increase in the summer compared to the No Action alternative. For example, in 1966, the elevation would decrease in spring by up to 3 feet and increase in summer by up to 3 feet (Figure 3-10).

Downstream from Gavins Point Dam, the May spawning cue release and summer low flow would remain well-defined in Omaha relative to flows under the No Action alternative (Figure 3-9). In this case, the Gavins Point Dam release is distinct from normal flows since contribution to the flow hydrograph can easily be distinguished. However, with increasing distance to Gavins Point Dam, flow releases would be increasingly attenuated in the lower river. The degree of attenuation would depend on inflow from major tributaries such as the Platte River (RM 595). For hydrologic conditions in 1966, the May spawning cue release and summer low flow would still be distinct from normal flows in Kansas City. In contrast, the March spawning cue release for hydrologic conditions in 1966 would be too small to be distinguished downstream of Gavins Point Dam.

The reduction in flow during the summer could result in missing flow targets. The 1966 Alternative 2 summer low flow in Omaha would be as low as 20,000 cfs in July, below the flow target of 25,000 cfs under the minimum service level. Low flows persist downstream and are distinct from normal flows downstream of Kansas City.

Conclusion

Under Alternative 2 higher flows may continue later in the fall and early winter in some years from low summer flows. Elevations in Lake Oahe would decrease in the spring and increase in the summer compared to Alternative 1. The May spawning cue release and summer low flow would remain well-defined in Omaha relative to flows under Alternative 1. However, with increasing distance to Gavins Point Dam, flow releases would be increasingly attenuated in the lower river. Overall, small, temporary, and long-term impacts on the river system from spawning cue releases, including changes in reservoir elevations and shoreline erosion in the upper three reservoirs, and degradation and aggradation in the inter-reservoir reaches along the upper river and the Gavins Point Dam reach to Ponca reach. Impacts could be large locally but impacts to hydrology are not anticipated to be significant under Alternative 2.

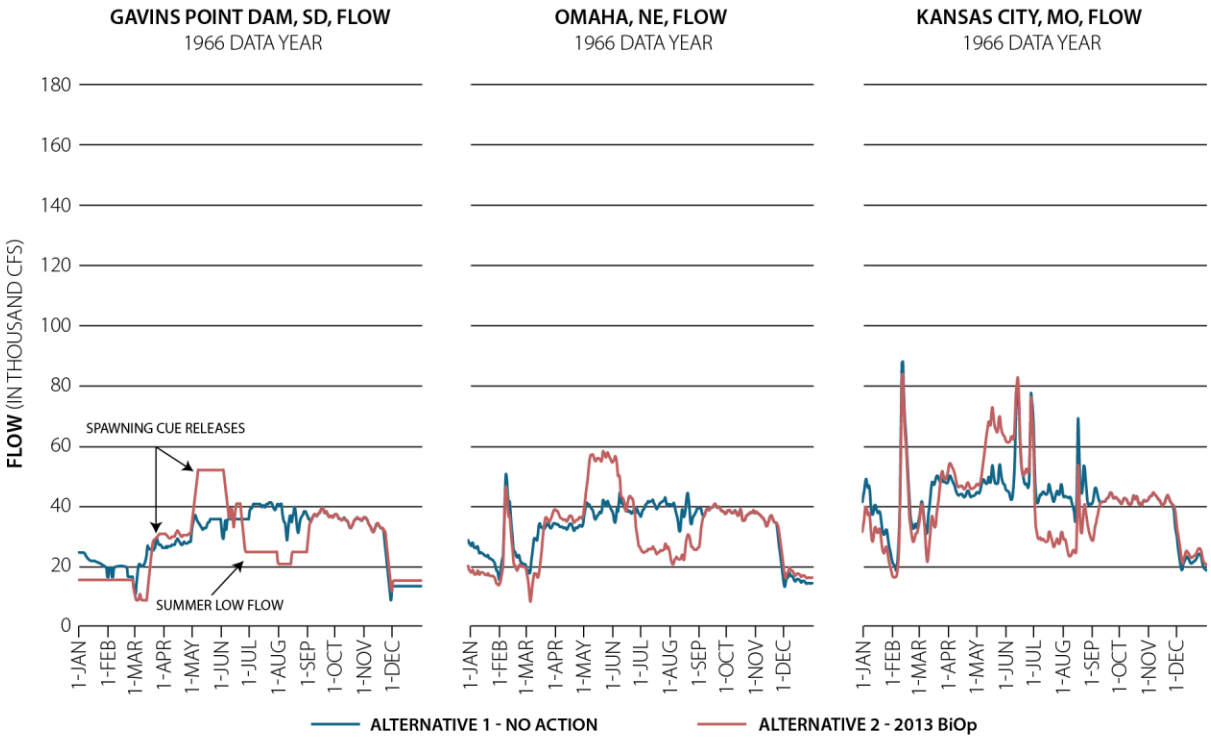


Figure 3-9. Flows of Missouri River at Gavins Point Dam, Omaha, and Kansas City under Alternatives 1 and 2, Simulated Based on Hydrologic Conditions in 1966

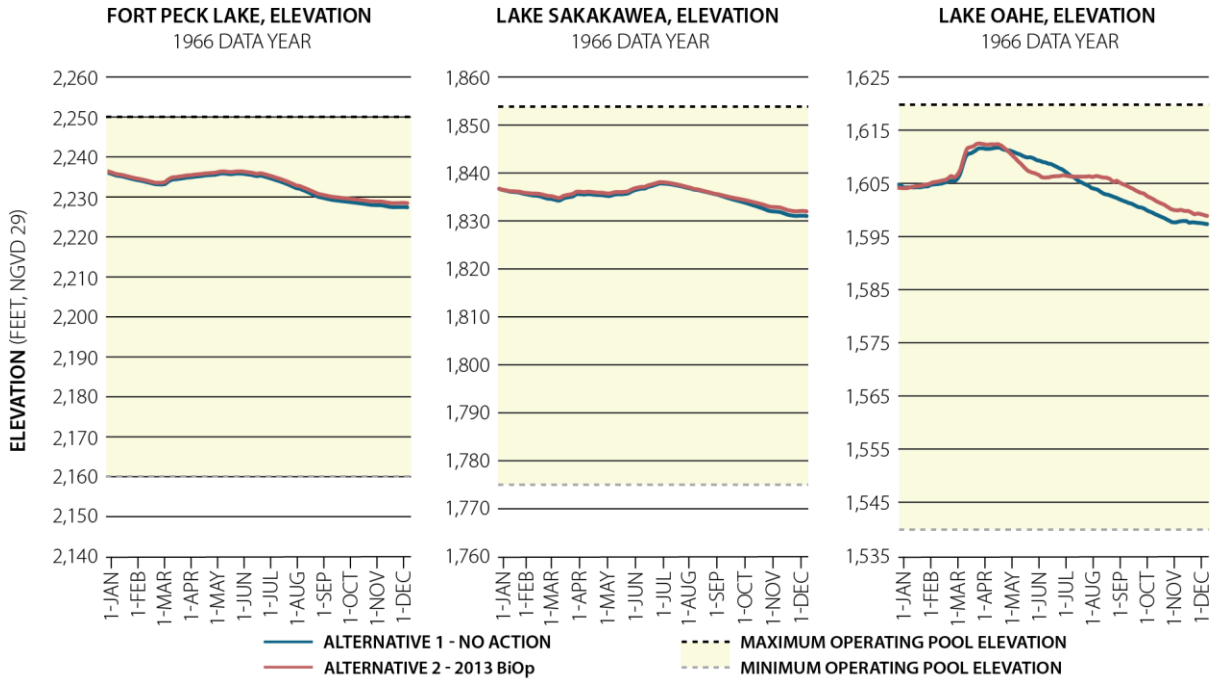


Figure 3-10. Elevations in Fort Peck Lake, Lake Sakakawea, and Lake Oahe under Alternatives 1 and 2, Simulated Based on Hydrologic Conditions in 1966

Alternative 3 – Mechanical Construction Only

Because of the localized nature of mechanical construction of ESH and IRC, this alternative would have negligible to no impacts on the overall hydrology in the river. The main difference would be the absence of the reoccurring March and May spawning cue release pulses included under the No Action alternative. For example, rules for the No Action alternative would allow for the release of these pulses to be initiated for hydrologic conditions in 1963 (Figure 3-11). As a result, reservoir elevations would be largely the same under both Alternatives 1 and 3 (Figure 3-12). In addition, flows throughout the year would also be similar because the small spawning cue releases under the No Action alternative would be rapidly attenuated downstream of Gavins Point Dam.

Conclusion

Overall, no to negligible impacts would occur on river hydrology compared to Alternative 1 because of the absence of the reoccurring spawning cue release and negligible changes to river flows and reservoir elevations. Impacts to hydrology are not anticipated to be significant under Alternative 3.

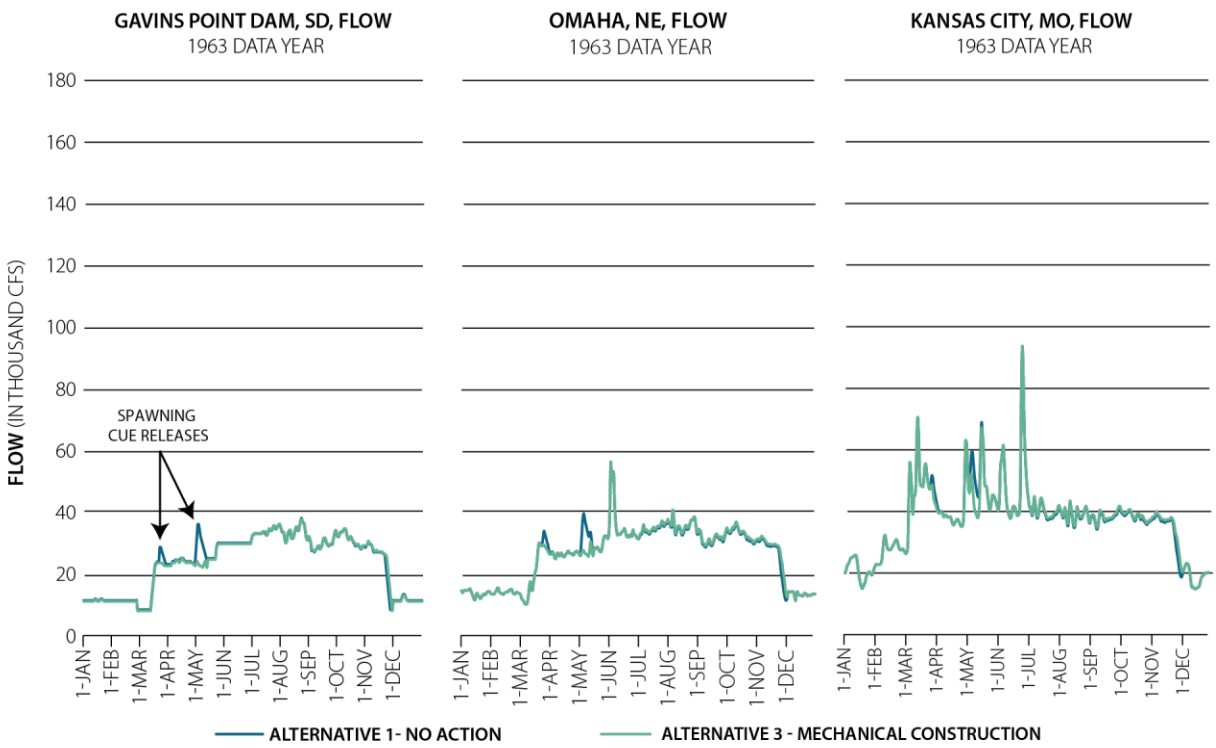


Figure 3-11. Flows of Missouri River at Gavins Point Dam, Omaha, and Kansas City under Alternatives 1 and 3, Simulated Based on Hydrologic Conditions in 1963

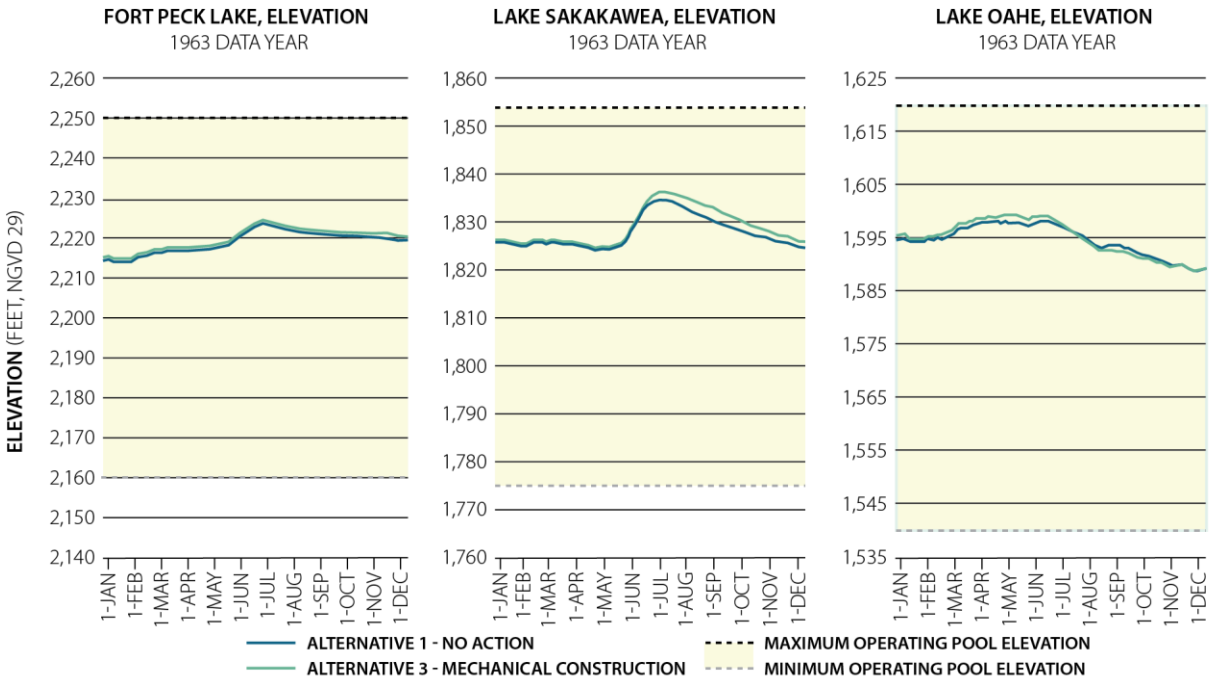


Figure 3-12. Elevations in Fort Peck Lake, Lake Sakakawea, and Lake Oahe under Alternatives 1 and 3, Simulated Based on Hydrologic Conditions in 1963

Alternatives 4 and 5 – Spring and Fall Habitat-Forming Flow Releases

Spring releases for ESH creation (Alternative 4) would start April 1 and would last between 35 days (at 60,000 cfs) and 175 days (at 45,000 cfs). Fall releases (Alternative 5) would be similar to spring releases, except they would start on October 15. Other constraints such as the flow rates (in cfs), duration (number of days), and frequency (as often as every 4 years) would be the same for both alternatives. Flows would be drawn primarily from Lakes Sakakawea and Oahe. After the ESH release, flows would be reduced because less water would be in storage.

Rules for Alternatives 4 and 5 would allow for these releases to be initiated for hydrologic conditions in 1974. The modeling results for this year are discussed to provide a sense of the effects from these releases. The spring flow release at Gavins Point Dam under Alternative 4 would have been 60,000 cfs, with flows decreasing in subsequent months (Figure 3-13). A similar flow release would have occurred under Alternative 5 in the fall (Figure 3-14). The reduction in flows under both Alternatives 4 and 5 would have lasted through 1975 before flows again would become similar to flows under the No Action alternative (Figure 3-15).

The spring and fall releases would decrease the elevations of Lakes Sakakawea and Oahe by several feet, by a maximum of 5 feet, lasting through 1975 (Figure 3-16 and Figure 3-17). The length of the storage recovery and the extent of the reduction in flow following a spring or fall release under Alternatives 4 or 5 would vary in different years and would depend on natural hydrologic conditions in that year.

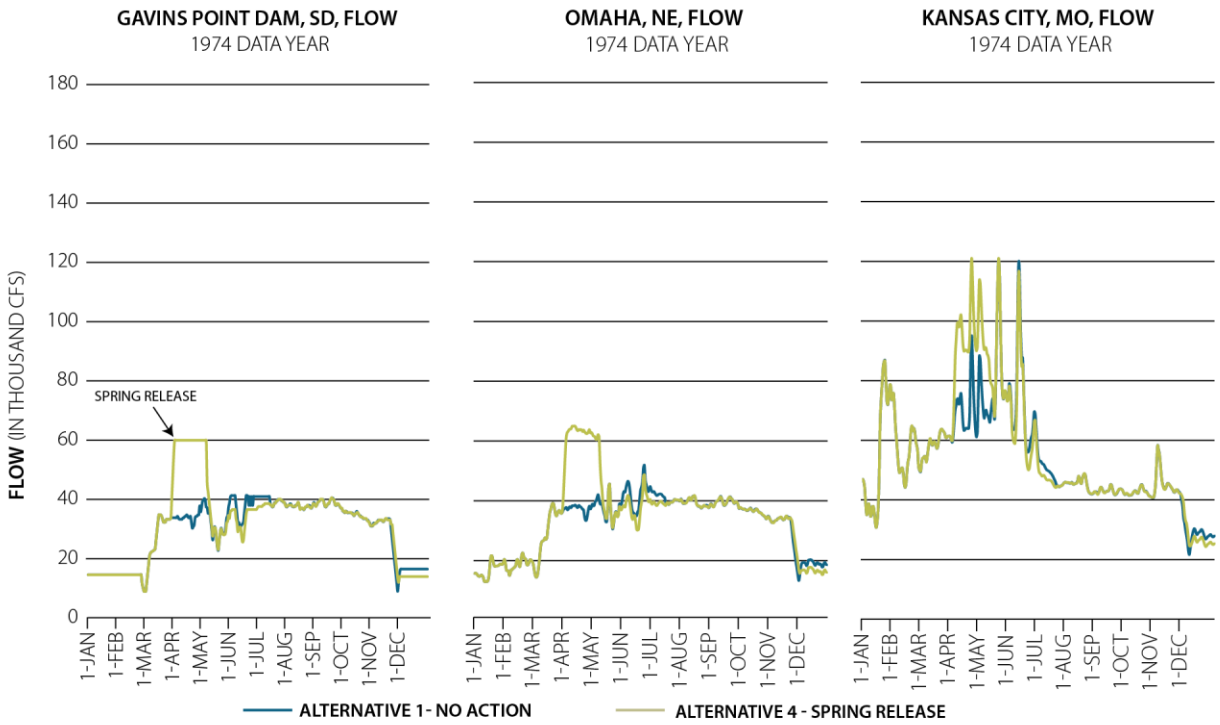


Figure 3-13. Flows of Missouri River at Gavins Point Dam, Omaha, and Kansas City under Alternatives 1 and 4, Simulated Based on Hydrologic Conditions in 1974

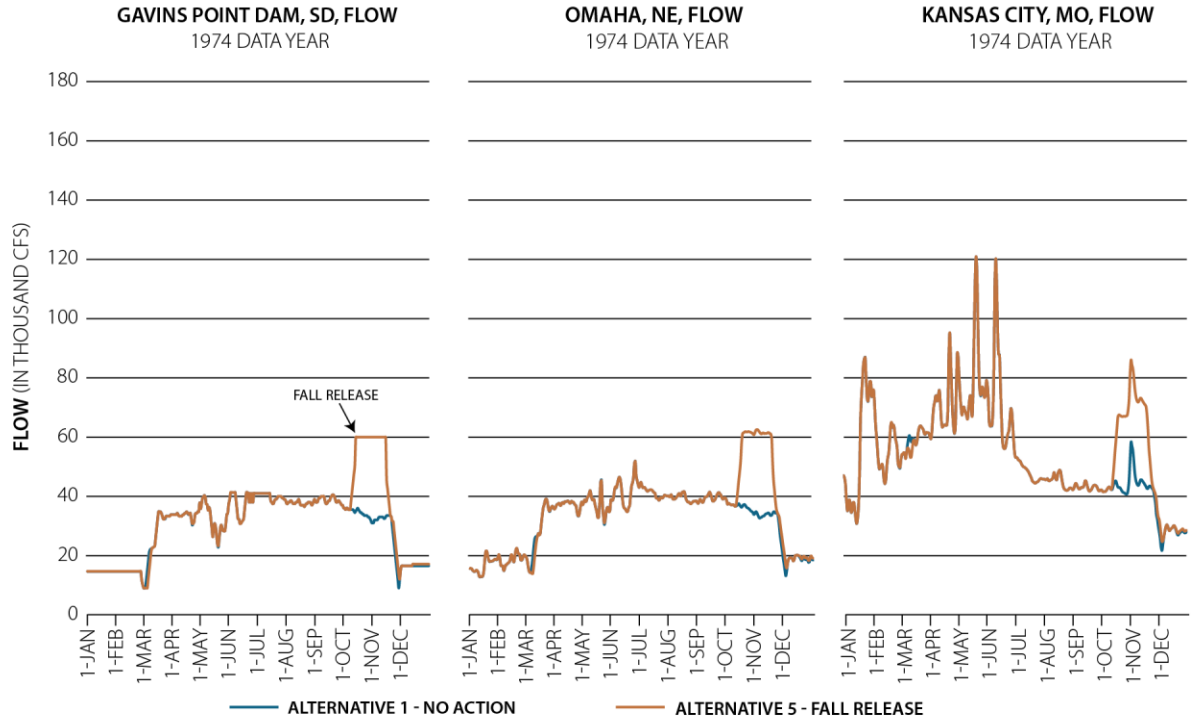


Figure 3-14. Flows of Missouri River at Gavins Point Dam, Omaha, and Kansas City under Alternatives 1 and 5, Simulated Based on Hydrologic Conditions in 1974

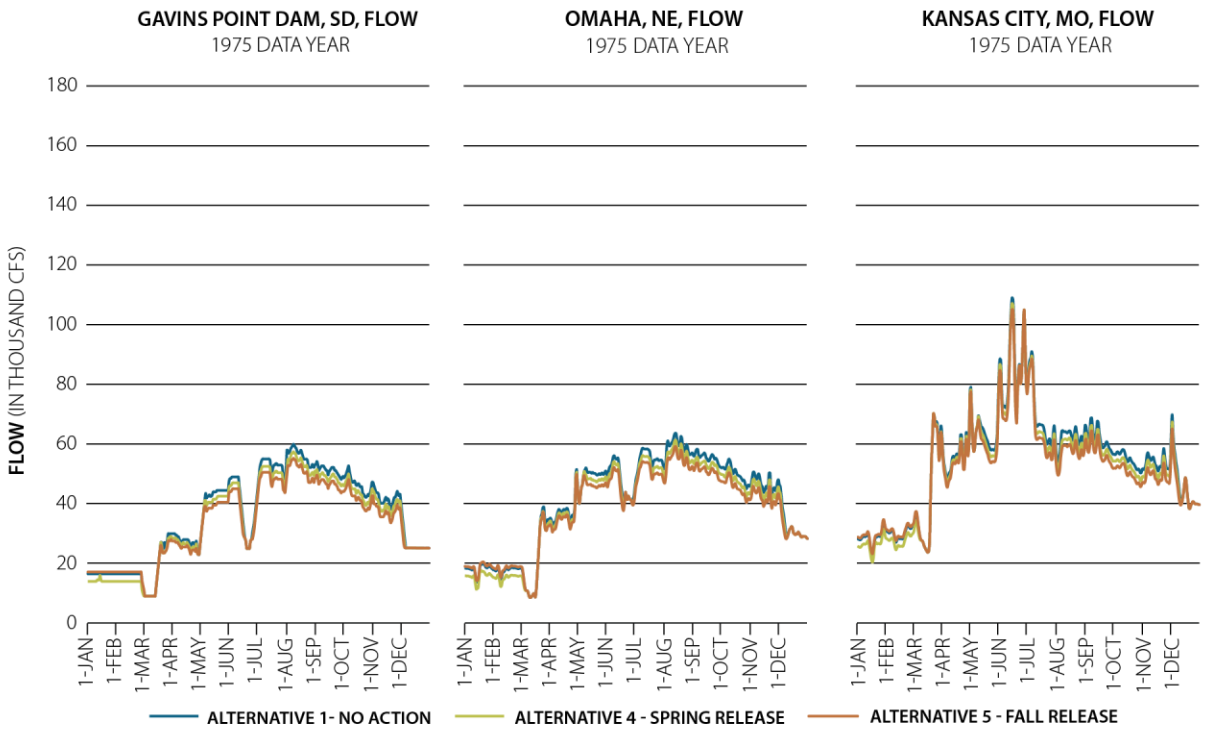


Figure 3-15. Flows of Missouri River at Gavins Point Dam, Omaha, and Kansas City under Alternatives 1, 4, and 5, Simulated Based on Hydrologic Conditions in 1975

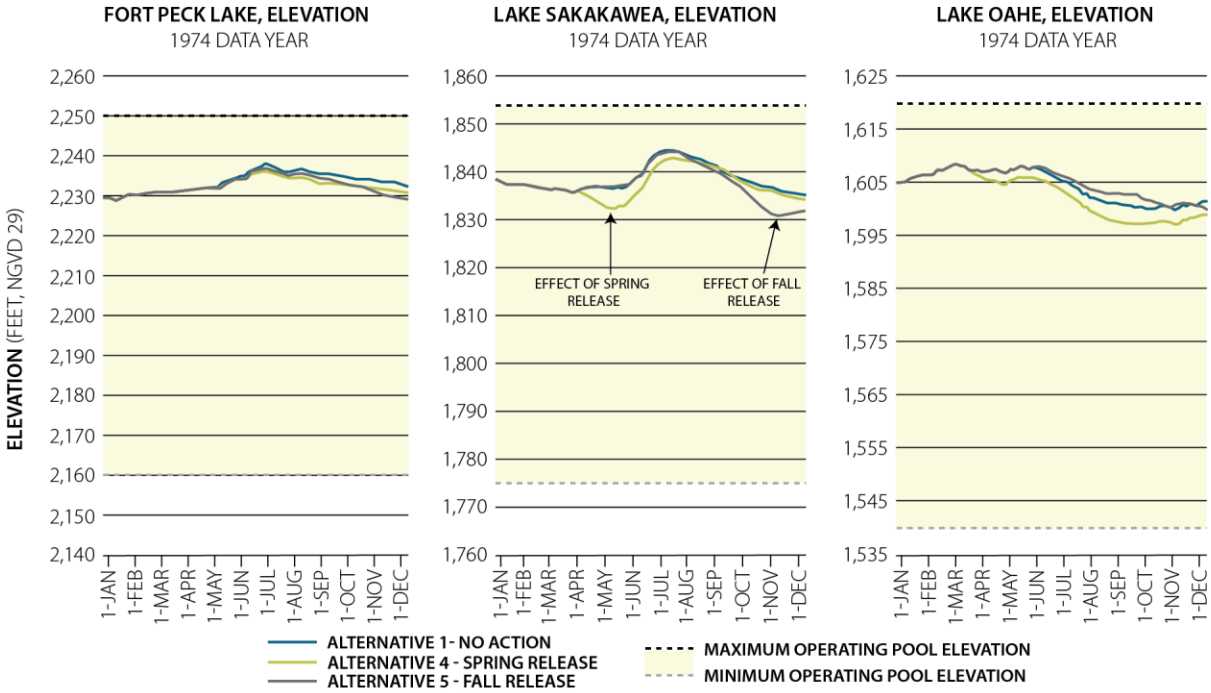


Figure 3-16. Elevations in Fort Peck Lake, Lake Sakakawea, and Lake Oahe under Alternatives 1, 4, and 5, Simulated Based on Hydrologic Conditions in 1974

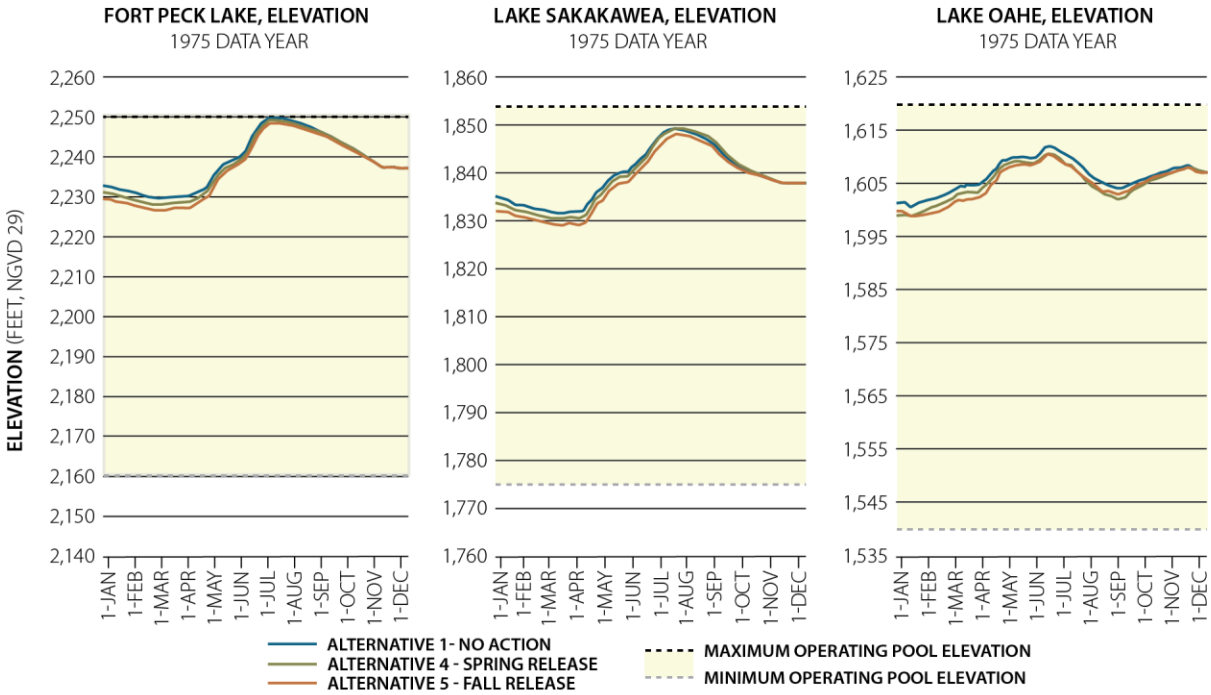


Figure 3-17. Elevations in Fort Peck Lake, Lake Sakakawea, and Lake Oahe under Alternatives 1, 4, and 5, Simulated Based on Hydrologic Conditions in 1975

Conclusion

Overall, small, temporary, and long-term impacts would occur to the river system from spring ESH creation releases, including changes in reservoir elevations in the upper three reservoirs compared to Alternative 1. Impacts could be large locally but would vary in different years and would depend on natural hydrologic conditions in that year. Small to negligible impacts would occur under Alternatives 4 and 5 in the lower river downstream of the Platte River confluence, because of gradual attenuation of flow releases with distance from Gavins Point Dam as a result of inflows from tributaries. Impacts to hydrology are not anticipated to be significant under Alternatives 4 and 5.

Alternative 6 – Pallid Sturgeon Spawning Cue

Rules for Alternative 6 would allow for March and May spawning cue releases to be initiated for hydrologic conditions in 1975. The modeling results for this year are discussed to provide a sense of the effects from these flows. The 2-day peaks would have occurred at Gavins Point Dam at the beginning of April and the beginning of June (Figure 3-18). To compensate for the released water, flows during the summer and fall would have been reduced by approximately 4,000 cfs compared to the No Action alternative. The maximum frequency for these flows is one event every 3 years.

Water for the 1975 spawning cue releases would have been drawn from Lake Oahe. Compared to the No Action alternative, the elevation of Lake Oahe would have been 4 feet lower after the May flow, but would have gradually recovered during the year (Figure 3-19). For hydrologic

conditions of other years, recovery of storage after Alternative 6 spawning cue releases could take 2 years.

As for flow releases under Alternatives 2, 4, and 5, the 1975 March and May peaks under Alternative 6 downstream of Gavins Point Dam would remain distinct near Omaha, but would be largely attenuated by background flow in Kansas City (Figure 3-18).

Conclusion

Overall, small, temporary, and long-term impacts would occur to the river system from spawning cue releases under Alternative 6, including changes in reservoir elevations in the upper three reservoirs compared to Alternative 1. Impacts to hydrology are not anticipated to be significant under Alternative 6.

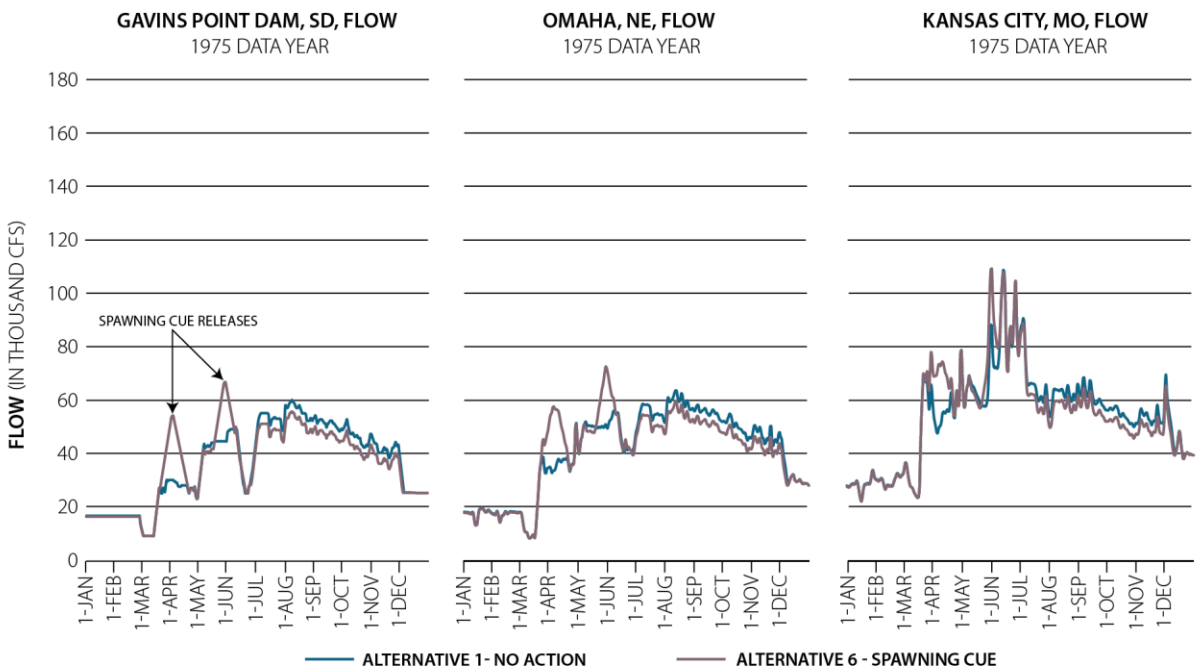


Figure 3-18. Flows of Missouri River at Gavins Point Dam, Omaha, and Kansas City under Alternatives 1 and 6, Simulated Based on Hydrologic Conditions in 1975

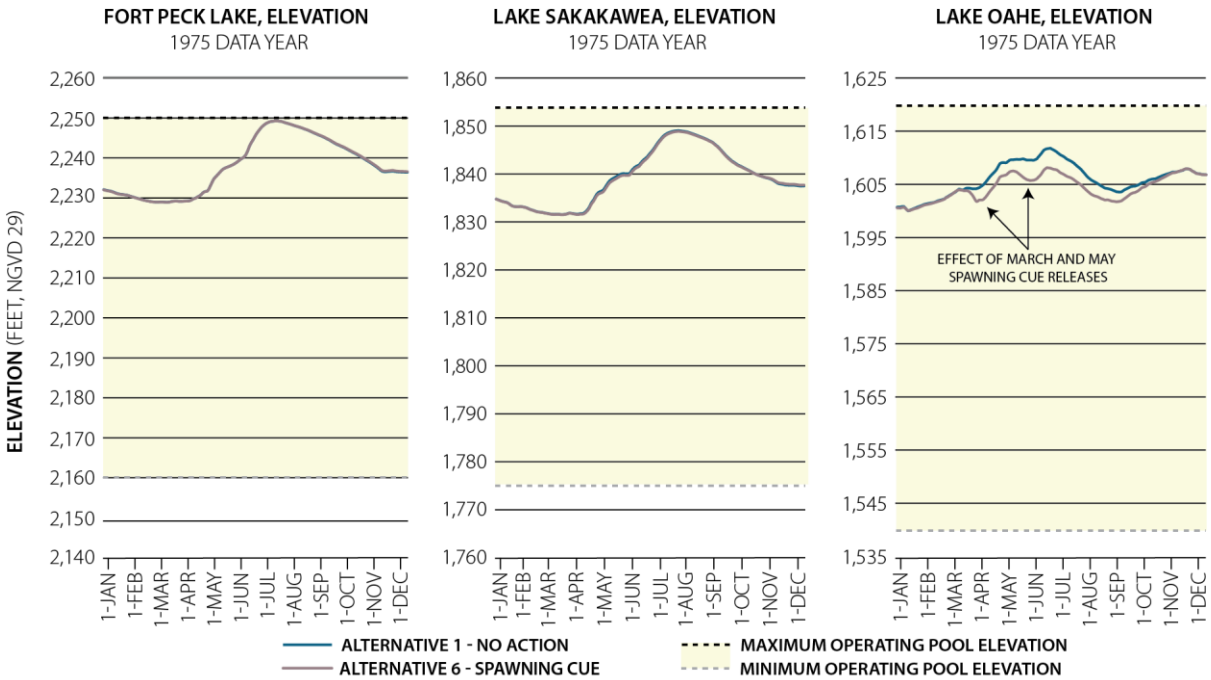


Figure 3-19. Elevations in Fort Peck Lake, Lake Sakakawea, and Lake Oahe under Alternatives 1 and 6, Simulated Based on Hydrologic Conditions in 1975

3.2.2.4 Impacts on Geomorphology from the Alternatives

None of the proposed management actions would change the total volume of water transported through the river system over the long term; only the timing of flow releases and flow rates would be altered and some dominant peak flows may be introduced by high releases. The total volume of sediment entering the river system from the watershed would also largely remain unchanged, although the dynamics of the altered flow release patterns may result in additional localized erosion or deposition of sediment within the river or reservoirs. This altered pattern may also affect the frequency of ice dam formation in the upper river.

Under Alternative 1, existing geomorphological processes and trends would continue (i.e., degradation and bank erosion, reservoir sediment deposition and aggradation, shoreline erosion in reservoirs, and ice dynamics).

Under Alternative 3, geomorphological processes would be similar to those described under Alternative 1 because of the effects of the absence of the reoccurring Alternative 1 spawning cue releases and the larger area of ESH construction under Alternative 3 would be minimal. Therefore, the following discussion of geomorphological impacts within individual reaches pertains only to releases under Alternatives 2, 4, 5, and 6.

Under all alternatives, ESH construction in the upper river and Gavins Point to Ponca reach would require excavating sediment from the river channel for ESH construction. Mechanical ESH construction was not evaluated with the HEC-RAS model. ESH would be designed to maintain conveyance of above-normal flows within the river channel and sediment would be taken from the vicinity of ESH construction sites. Sediments would not be taken from the thalweg with consolidated (and potentially armored) materials, and no new material would be

brought into the system from upland sources. For each acre of ESH constructed, approximately 2 acres of borrow area for the needed material (i.e., sand) would be disturbed (USACE 2011). A more extensive discussion on ESH construction is presented in Section 3.4, Piping Plover and Least Tern.

Degradation and Bank Erosion: Degradation refers to the lowering of the riverbed as a result of erosion coupled with a lack of resupply of sediment from upstream sources because sediments are trapped by the dams. Degradation causes impacts such as erosion of streambanks and the riverbed, erosion around river infrastructure and recreational boating facilities, lowering of the groundwater table in the floodplain, and potential conversion of some wetland areas to upland. Streambank failure rates are a function of multiple factors, including high flows and the repetitive wetting/drying of bank materials. Impacts by river reach would be as follows:

- **Fort Peck Dam to Lake Sakakawea**: Flow releases under Alternatives 2, 4, 5, and 6 could have temporary and localized impacts. However, this inter-reservoir reach is the most stable reach, and incremental differences of flow releases from Fort Peck Dam under these four alternatives would be small compared to differences in the reaches below Garrison and Oahe Dams.

  Long-term impacts in addition to degradation and streambank erosion under Alternative 1 would be considered small. Highest overall erosion and sediment transport processes would continue to be largely affected by natural precipitation and snow melting conditions, such as the peak flow event experienced in 2011 (West Consultants 2013).

  Mechanical ESH construction would not occur in this reach, and therefore, no impacts from these actions would occur.

- **Garrison Dam to Lake Oahe**: Similar to the Fort Peck Dam to Lake Sakakawea reach, flow releases under Alternatives 2, 4, 5, and 6 could have temporary and localized impacts. For example, recorded high flows at Garrison Dam (RM 1390) occurred in 1996 and 1997, with flows during the spring and summer of 42,000 cfs for 5 months (1996) and flows from spring through the fall of approximately 50,000 cfs for more than 6 months (1997). At the gage near Stanton, North Dakota (RM 1379, located 11 river miles downstream of Garrison Dam) these recorded flows did not result in a noticeable change in the degradation rate (USACE 2012a). Farther downstream, at the Hensler (RM 1362) and Washburn (RM 1355) gages, the high flows of 1996 and 1997 lowered the stage by approximately 1 to 1.5 feet; however, as a result of subsequent low flows, the stage recovered by up to 0.5 foot and then remained at the same level until 2010. Alternatives 4 and 5 could result in flow releases at Garrison Dam of 42,000 cfs for approximately 1 month. Considering the observations after recorded flows in 1996 and 1997, degradation of the river channel from the much shorter Alternatives 4 or 5 flow releases would perhaps be on the order of up to 0.5 foot in the mid-section of the Garrison Dam to Lake Oahe reach for each release.

  Considering the temporary impacts from individual releases and because Alternatives 4 or 5 full flow releases would occur only approximately every 10 or 7 years (Table 3-4), respectively, long-term impacts from additional degradation and streambank erosion under Alternatives 4 and 5 would be considered small. Under Alternatives 2 and 6, changes in flow from Garrison Dam would be comparatively small, thus overall additional degradation and streambank erosion would also be small in this reach. However, impacts could be greater at specific locations from individual releases or from accelerated degradation rates long term.

The portion of the total annual mechanical ESH construction that would occur in this reach annually, in years where construction is needed, on average varies by alternative (i.e., Alternative 1 – 62 acres; Alternative 2 – 1,383 acres; Alternative 3 – 160 acres; Alternative 4 – 29 acres; Alternative 5 – 99 acres; Alternative 6 – 100 acres). Impacts from mechanical ESH construction in this reach would include the same overall impacts described for Alternatives 1, 3, 4, 5, and 6 and would be small or negligible and local in nature. The impacts from mechanical ESH construction under Alternative 2 would be larger in this reach due to the larger amounts of ESH and could include changing flow patterns that may result in degradation and bank erosion.

- **Oahe Dam to Lake Sharpe**: This reach is relatively stable because of the short distance of open water and the implementation of protective measures. Degradation and shoreline erosion from any of the alternatives would be negligible.

  Mechanical ESH construction would not occur in this reach, and therefore, no impacts from these actions would occur.

- **Fort Randall Dam to Lewis and Clark Lake**: Flow releases under Alternatives 2, 4, 5, and 6 could result in additional degradation and streambank erosion. The extent of erosion would be smaller than in other inter-reservoir reaches upstream because the soils downstream of Fort Randall Dam are less erodible.

  For the recorded high flows in 1996 and 1997 that ranged between 50,000 cfs and 80,000 cfs for a total of approximately 11 months, the river stage at the Greenwood gage (RM 863, located 17 miles downstream of Fort Randall Dam) only decreased by approximately 0.5 foot and recovered by approximately 3 inches in the following year (USACE 2012b). Therefore, long-term impacts related to flow releases from additional degradation and streambank erosion in this inter-reservoir reach would be considered small.

  Mechanical ESH construction would not occur in this reach under Alternative 1. The portion of the total annual mechanical ESH construction that would occur in this reach annually on average varies by alternative (i.e., Alternative 2 – 780 acres; Alternative 3 – 12 acres; Alternative 4 – 12 acres; Alternative 5 – 12 acres; Alternative 6 – 9 acres). Impacts from mechanical ESH construction in this reach would include the same overall impacts described for Alternatives 3, 4, 5, and 6 and would be small or negligible and local in nature. The impacts from mechanical ESH construction under Alternative 2 would be larger in this reach and could include changing flow patterns that may result in degradation and bank erosion.

- **Missouri River from Gavins Point Dam to Ponca, Nebraska**: For the 11-month-long recorded high flows in 1996 and 1997, the long-term trend of decreasing river stage at the Yankton gage (RM 805.8, located 5.3 miles downstream of Gavins Point Dam) was not noticeably affected (USACE 2014b). The recorded river stage at the Gayville gage (RM 796, located 15 miles downstream of Gavins Point Dam) decreased by approximately 2 feet and fully recovered by 2010 (USACE 2014b). At the Ponca gage (RM 751, located 60 miles downstream of Gavins Point Dam), the stage in the river decreased by approximately 3 feet and recovered 2 feet by 2010. The flood of 2011, with recorded sustained flows of 160,000 cfs for 2 months, resulted in a drop in stage at Ponca by 5 feet; data of the recovery of the stage subsequent to the flood are not yet available.

  Erosion rates for the recorded high-flow period of 1995 to 1997 were 275 acres per year, followed by rates of 69 acres per year in the subsequent low-flow period from 1998 to

2008. During the period 2008 to 2011 (including the large flood of 2011), erosion rates were 142 acres per year, suggesting that bank erosion rates may be slowing, and the river is gradually getting closer to reaching a state of equilibrium.

In light of the effects from the recorded high-flow, long-lasting events in 1996–1997 and 2011, and considering the lower flow rates and shorter duration of the proposed flow releases under Alternatives 2, 4, 5, and 6, additional degradation and streambank erosion would likely occur from individual flow releases, but impacts on degradation rates and streambank erosion rates would be considerably smaller than during these two flood periods.

Overall long-term impacts related to flow releases from additional degradation and streambank erosion in this reach are expected to be small, although they could be large locally from individual releases or from accelerated degradation rates.

The portion of the total annual mechanical ESH construction that would occur in this reach annually on average varies by alternative (i.e., Alternative 1 – 45 acres; Alternative 2 – 780 acres; Alternative 3 – 219 acres; Alternative 4 – 199 acres; Alternative 5 – 198 acres; Alternative 6 – 194 acres). Impacts from mechanical ESH construction in this reach would include the same overall impacts described for Alternatives 3, 4, 5, and 6 and would be small or negligible and local in nature. The impacts from mechanical ESH construction under Alternative 2 would be larger in this reach and include changing flow patterns that could result in degradation and bank erosion.

- **Missouri River from Ponca to St. Louis**: Additional degradation (on the order of inches, on average) would be expected between Ponca and the Platte River confluence during spring and fall flow releases under Alternatives 4 and 5. At the Sioux City gage, the recorded high 1996 and 1997 flows resulted in a decrease in stage by approximately 2 feet, with a 1-foot recovery of the stage by 2010. The flood of 2011, with recorded flows of approximately 180,000 cfs near Sioux City, resulted in a drop in stage by 3 feet (USACE 2014c). At Omaha, the 1996 and 1997 recorded flows resulted in a drop in stage by about 1 foot that remained approximately the same until 2010; the flood of 2011 resulted in a drop in stage by approximately 1 to 2 feet.

  Long-term impacts from flow releases under Alternatives 2, 4, 5, and 6 would be small because of the numerous flow control structures along the streambank and the gradual attenuation of the flow releases with distance from Gavins Point Dam.

  Mechanical ESH construction would not occur in this reach, and therefore, no impacts from this action would occur. Under all alternatives, channel reconfiguration would be conducted in the lower river between Ponca and St. Louis to create early life stage pallid sturgeon habitat, although the amounts and types of habitat that would be created would vary by alternative. Specifically, channel reconfiguration could include adjustments to navigation training or bank stabilization structures, channel widening (e.g., Figure 3-7), floodplain modifications or other adjustments to channel geometry, or chute development or modifications. See Section 2.5.3.1 for design specifications. Overall, temporary and long-term impacts from these measures would be small because these projects would be comparatively local in nature. Some of the sediment would be suspended into the water column or discharged to the thalweg, where it would be transported downriver as bedload.

Reservoir Sediment Deposition and Aggradation: Aggradation of the riverbed could cause impacts such as flooding, conversion of cropland to wetlands, higher groundwater elevations, and shoaling around infrastructure for recreational boating—all of which would affect private

property. Aggradation would be affected by altered reservoir elevations in the upper three reservoirs that would affect the locations of sediment deposition. The specific locations would vary from year to year and would have to be modeled; such detail is currently not available but would be addressed through monitoring and adaptive management under any implemented action alternative. Impacts by river reach would be as follows:

- **Fort Peck Dam to Lake Sakakawea**: Because impacts on erosion in this reach from flow releases under Alternatives 2, 4, 5, and 6 would be small and the sediment supply from the Yellowstone River would be unaffected by the proposed management actions, temporary impacts on aggradation in this reach would be considered local in scale and overall small. Long-term impacts would also be small for the same reasons.

  Mechanical ESH construction would not occur in this reach, and therefore, no impacts from this action would occur.

- **Garrison Dam to Lake Oahe**: Small impacts would occur from year to year in the aggrading stretch of this inter-reservoir reach during individual flow releases under Alternatives 2, 4, 5, and 6, which would result in temporary and localized variability in sediment deposition in some areas and riverbed scour (increasing the channel capacity) in other areas.

  Considering that long-term additional degradation and streambanks erosion would occur under Alternatives 2, 6, and particularly 4 and 5, additional aggradation in the downstream stretch of the reach and the delta is expected. Long-term, additional aggradation would be small in this reach, although long-term impacts could be large locally.

  Sediment mobilized upstream in this reach as a result of mechanical ESH construction would contribute to aggradation in the Lake Oahe delta and the riverbed just upstream of the delta. This contribution would be a function of the volume of sediment mobilized due to mechanical ESH construction. Therefore, aggradation would be highest under Alternative 2 which has the largest acreage of mechanical ESH construction, and substantially smaller under Alternatives 1, 3, 4, 5 and 6.

- **Fort Randall Dam to Lewis and Clark Lake**: Considering that long-term impacts on erosion in this reach from flow releases under Alternatives 2, 4, 5, and 6 would be small, the temporary impacts from flows on aggradation in this reach under these action alternatives would also be considered generally small. However, different impacts may occur as a result of sediment supply from the Niobrara River that deposits its sediment bedload in the Missouri River at the confluence (Figure 3-5). Experience has shown that channel capacity in the Fort Randall reach changes year-to-year depending on recent release levels. Year after year of low releases reduce channel capacity from the accumulation of additional sediment, while high flows like those experienced in 1997 and 2011 increase channel capacity as sediment is flushed downstream. Current channel capacity is approximately 35,000 to 40,000 cfs. Therefore, should the altered flows during Alternatives 2, 4, 5, and 6 result in removing a smaller amount of the accumulated Niobrara River sediment, the higher stage in the Missouri River in the vicinity of the Niobrara River delta could result in upstream flooding and elevated groundwater levels along the Missouri River for a stretch of approximately 5 to 10 miles during individual releases, which would constitute a large impact in this stretch.

  Sediment mobilized upstream in this reach as a result of mechanical ESH construction would contribute to aggradation in the Lewis and Clark Lake delta and the riverbed just upstream of the delta. This contribution would be a function of the volume of sediment

mobilized due to mechanical ESH construction. Therefore, aggradation would be highest under Alternative 2 which has the largest acreage of mechanical ESH construction, and substantially smaller under Alternatives 3, 4, 5 and 6. There would not be mechanical ESH construction in this reach under Alternative 1, thus no contribution to aggradation.

- **Gavins Point Dam to St. Louis**: Aggradation in the lower river would be localized and would largely be a function of sediment supplied by inflowing tributaries. Summer low flows under Alternative 2 may result in temporary sediment accumulation in the lower river channel because flows could be too low to achieve the self-scouring that the river was designed for to accommodate navigation. As a result, localized dredging may be required during low summer flow conditions.

  Long term, flow releases under Alternatives 2, 4, 5, and 6 would have small to negligible impacts on aggradation, particularly in the channelized, generally self-scouring lower river downstream of Ponca. However, a reconfigured and widened channel may result locally in sediment deposition.

  There would be no aggradation in this reach as a result of mechanical ESH construction (as there is no reservoir downstream resulting in a sharp decrease in flow velocity), except in local spots within the reach where flow velocities in the river are reduced as a result of the newly created sand bars. This effect would be relatively larger under Alternative 2 due to its larger acreage of mechanical ESH construction.

  Channel reconfiguration projects in the lower river would be designed and constructed in a manner to avoid aggradation in the river channel in order to avoid impacts on navigation.

Shoreline Erosion in Reservoirs: Generally, shoreline erosion rates in the reservoirs are much higher at higher reservoir elevations. In the lower three reservoirs (Francis Case Lake, Lake Sharpe, and Lewis and Clark Lake) elevation changes as a result of the proposed management actions would be small, resulting in negligible, temporary, and long-term shoreline erosion impacts.

Elevations in the three large upper reservoirs (Fort Peck Lake, Lake Sakakawea, and Lake Oahe) are more variable because they are used for flood control (i.e., controlling the variability in natural flows). Lake Francis Case also experiences annual elevation variation. Under Alternatives 2, 4, 5, and 6, the flow modifications would temporarily alter the elevations in the reservoirs and hence expose the shorelines to altered patterns of erosion and sediment redeposition. Specifically, added fluctuations from the action alternatives could result in additional shoreline erosion as a result of the wetting and drying cycle. These patterns would vary from year to year because they are dependent on meteorological conditions. These conditions include natural precipitation in the watershed that affects overall reservoir elevations and wind that affects wave height and direction. In individual years, differences in reservoir elevations as a result of Alternatives 2, 4, 5, and 6 may range from a few feet up to approximately 10 feet, compared to elevations under the No Action alternative. However, the operating ranges of 90 feet (Port Peck Lake), 79 feet (Lake Sakakawea), and 80 feet (Lake Oahe) are substantially larger than the variability in reservoir elevation that would result from the management actions under the action alternatives, although typically the reservoirs do not vary by that much. Based on the statistical analysis of the POR, the ranges between the 90th and 10th percentile elevations are approximately 40 feet for Port Peck Lake and Lake Oahe and 35 feet for Lake Sakakawea (Figures D-2 to D-4 in Appendix D).

Therefore, temporary and long-term impacts on shoreline erosion and sediment redeposition would be small and would vary along the shoreline from year to year because the overall reservoir elevations (and thus the overall sediment erosion and redeposition patterns) are driven primarily by natural precipitation. However, locally, shoreline erosion impacts could be large due to factors such as bank material type, prevailing wind direction, and ice dynamics.

Mechanical ESH construction would occur in Lewis and Clark Lake under Alternative 2. The portion of the total annual mechanical ESH construction that would occur in this reach annually on average would be 603 acres. There could be some reworking of the constructed sandbars from wave action. Geomorphological impacts are expected to be negligible.

Ice Dynamics: Releases under Alternatives 2, 4, 5, and 6 may result in localized changes in the pattern of regular ice formation that would occur under the No Action alternative. For example, sand bars created by flow releases under Alternatives 4 and 5 or by mechanical construction could result in local ice jams that could erode the shoreline or result in flooding. Aggraded areas in the upper delta within reservoirs could result in ice jams forming farther upriver, potentially causing flooding in upriver communities. However, temporary and long-term impacts are expected to be small and would be highly dependent on meteorological conditions in any particular year. Standard operations of the mainstem reservoir System by USACE include measures to minimize impacts from annual ice formations.

Conclusions

Overall, conclusions of impacts to geomorphology for each of the alternatives are included in Table 3-3. Continued degradation of the river channel and bank erosion in the reaches below the dams as a result of a lack of resupply of sediment would occur under Alternative 1. Continued aggradation of the riverbed upstream of reservoirs under Alternative 1 could occur as a result of redeposition of eroded sediment from the degrading part of the mainstem and its banks and the influx of sediment from tributaries. Streambank erosion in aggrading river reaches and erosion of reservoir shorelines would continue under Alternative 1.

Temporary, localized aggradation in the lower river from low summer flows that could require dredging would occur under Alternative 2. Small, temporary, and long-term impacts would occur from spawning cue releases from shoreline erosion in the upper three reservoirs and degradation and aggradation in the inter-reservoir reaches along the upper river and the Gavins Point Dam to Ponca reach would occur under Alternative 2. These impacts could be large adverse locally.

Small, temporary, and long-term impacts would occur from spawning cue releases to geomorphology under Alternative 3.

Small, temporary, and long-term impacts would occur from spring ESH creation releases from shoreline erosion in the upper three reservoirs and degradation and aggradation in the inter-reservoir reaches along the upper river and the Gavins Point Dam to Ponca reach would occur under Alternative 4. These impacts could be large adverse locally.

Impacts similar to those described under Alternative 4 would occur under Alternative 5 but would occur in the fall instead of the spring.

Small, temporary, and long-term impacts would occur from spawning cue releases from shoreline erosion in the upper three reservoirs and degradation and aggradation in the inter-

reservoir reaches along the upper river and the Gavins Point Dam to Ponca reach would occur under Alternative 6. These impacts would be smaller under Alternative 6 compared to Alternative 4 because of the smaller volume of water released from the System.

Impacts to geomorphology would not be significant under any of the alternatives.

3.2.2.5 Impacts on Riverine Infrastructure from the Alternatives

The constant forces of flowing water acting on the riverine infrastructure built by USACE and other organizations would continue to require maintenance under the No Action alternative. These structures are generally maintained a few feet above the navigation season normal water level. Alternatives that result in additional flow variability, with more frequent overtopping of channel structures, would result in higher maintenance requirements. Locally, the type of maintenance required would depend in part on local hydrologic conditions and the condition of individual infrastructure components.

Under Alternative 3, negligible or no temporary or long-term impacts on riverine infrastructure are expected because mechanical construction would not affect the flow rate or stage in the river and the absence of the spawning cue release of the No Action alternative would have a negligible effect. Therefore, the following discussion pertains to Alternatives 2, 4, 5, and 6. In essence, flow releases could result in temporary and localized impacts on riverine infrastructure as follows:

- **Reservoir Dams**: The flow release magnitude exceeds the power plant capacity at all projects except Big Bend. Past operations experience has shown that using the spillway or flood tunnels to release flow for a prolonged period results in the need for additional maintenance of these features and adds cost to operating the system. Long-term reliability of flow release features (spillway and/or flood tunnel) may also be affected. Finally, minor changes in dam safety risk from the use of additional release mechanisms and pool levels may occur. These risks have not been quantified at this time and would require a Monte Carlo analysis to evaluate changes in operation frequency and pool probability.
- **Bank Stabilization Structures in Inter-Reservoir Reaches in the Upper River and the Gavins Point Dam to Ponca State Park Reach in the Lower River**: Bank stabilization structures were built under various authorities in the 1970s. These structures consist mostly of rock structures and are managed by local authorities. Some of these structures are currently in poor condition. More frequent overtopping would result in higher wear and tear on these structures. Structures may also erode in degrading river reaches and be buried in areas of aggradation. Generally, impacts on these structures would be localized and associated with individual flow releases. Overall, long-term impacts under Alternatives 2, 4, 5, and 6 are considered small, considering the wide range of natural and system-controlled variability in flows and geomorphological processes.
- **Lower River Structures**: The lower river downstream of Ponca is channelized through multiple dikes, wing dams, levees, and other structures. Generally, impacts on these structures would be localized and associated with individual flow releases. USACE conducts annual maintenance of navigation structures. Flood relief funds in addition to normal maintenance funds are normally required to repair high flow event damage. Overall, long-term impacts under Alternatives 2, 4, 5, and 6 would be considered small, in the range of $1 to $2 million (which is an increase of up to about 20 percent in annual

maintenance costs). Minor changes in structure maintenance are forecasted because of the wide range of natural and system-controlled variability in flow and geomorphological processes.

- **Navigation Channel**: Under the No Action alternative, dredging because of shoaling in the lower river is rarely required; this low frequency of dredging is not expected to increase under Alternatives 3–6. Under Alternative 2, low summer flows are projected to require additional localized dredging in the lower river to maintain navigation channel dimensions. The temporary and long-term impacts would likely be limited to the bend scale. The affected area would be small and would depend in part on meteorological conditions in the Missouri River watershed.

In summary, if a flow alternative were implemented, the increased maintenance needs of rock structures in the upper and lower river would increase operating and maintenance costs. These structures are usually maintained at a level a few feet above the normal water level. Long-term flows with more overtopping would result in additional maintenance needs. Similarly, long-term risk of structure failure, especially for those structures in poor condition that have not been maintained adequately, would also increase. These costs and risks have not been quantified.

Conclusions

Overall, conclusions of impacts to riverine infrastructure for each of the alternatives are included in Table 3-3. Changing flows would affect river infrastructure locally under Alternatives 1, 2, 4, 5, and 6. Negligible impacts would occur to river infrastructure from changing flows under Alternative 3 due to the absence of the reoccurring flow management actions.

Impacts to river infrastructure would not be significant under any of the alternatives.

3.2.2.6 Impacts on Groundwater from the Alternatives

Groundwater elevations in the floodplain and upland areas adjacent to the river are primarily affected by stage in the river. On a shorter time scale (a season to a few years), the river stage varies because of flow rate. On a longer time scale, the river stage is affected also by a decrease or increase of the river channel elevation from degradation or aggradation, respectively. Over the long term, higher groundwater elevations as a result of a higher river stage, for example, could gradually convert upland (including cropland) to wetland areas or could increase soil moisture levels in cropland areas. Conversely, lower groundwater elevations over the long term could drain wetland areas and convert them into upland areas.

Under the No Action alternative, existing effects on groundwater in the floodplain and areas adjacent to the river from System operation would continue. Groundwater levels would rise or fall with prolonged periods of high or low flows, respectively. Groundwater effects for Alternative 3 would be similar to the No Action alternative because of the absence of the No Action spawning cue releases would have a negligible effect.

Higher river stages during flow releases under Alternatives 2, 4, 5, and 6, as well as lower river stages during low summer flows under Alternative 2 would have overall, small and temporary impacts on groundwater elevations. However, individual flow releases could cause local impacts in some inter-reservoir reaches (Garrison Dam to Lake Oahe, Fort Randall Dam to Lewis and Clark Lake, and perhaps Big Bend Dam to Lake Case Francis) if the released volume exceeds the channel capacity in the upper reservoir delta regions. This includes the stretch of 5 to 10

miles upstream of the Niobrara River confluence. The elevated river stages during such releases could result in higher groundwater levels, potentially causing damage to property.

Considering the effects on river stage from natural variability in precipitation and because the impact from Alternatives 2, 4, 5, and 6 on degradation and aggradation of the riverbed would be small, the long-term impact on groundwater elevations under these action alternatives would also be small, but could be large locally.

In areas on channel reconfigurations in the lower river between Ponca and St. Louis, small, localized, long-term impacts on groundwater elevations could occur under all alternatives. These impacts would depend on the specific type of project and local site conditions.

Conclusions

Overall, conclusions of impacts to groundwater for each of the alternatives are included in Table 3-3. Changing flows would affect groundwater levels locally under Alternatives 1, 2, 4, 5, and 6. No impacts would occur to groundwater levels from changing flows under Alternative 3 due to the absence of the reoccurring flow management actions.

Impacts to river infrastructure would not be significant under any of the alternatives.

3.2.2.7 Climate Change

In August 2016, the CEQ released final guidance for federal agencies on how to consider the impacts of their actions on climate change in their NEPA review. The final guidance provides a level of predictability and certainty and allows decision makers and the public to more fully understand the potential climate impacts of all proposed federal actions, and in turn, assist agencies in comparing alternatives and considering measures to mitigate the impacts of climate change.

USACE (2016) assessed how climate change could potentially change the effects of the alternatives. The “Climate Change Assessment – Missouri River Basin” report is available online (www.moriverrecovery.org). Main climate change consequences under the various alternatives are summarized in Table 3-5. USACE climate change guidance and most references from other sources for the Missouri River basin agree that future climate trends will likely consist of increased temperatures and precipitation. Increased precipitation will result in higher streamflow, while increased temperatures will likely result in earlier spring snowmelt, decreased snowmelt season duration, and decreased peak snowmelt flows. Increased air temperatures could also have impacts on water temperatures and water quality, which could exacerbate impacts of alternatives with low summer flows. Rainfall events will likely become even more sporadic for the entire Missouri River basin. Large rain events will likely become more frequent and interspersed by longer relatively dry periods. Extremes in climate will likely also magnify periods of wet or dry weather, resulting in longer, more severe droughts, and larger more extensive flooding.

The higher streamflow and increased sporadic flood and drought periods could prove challenging for reservoir regulation and would affect all alternatives as follows:

- **Hydrology**: Flow releases under Alternatives 1, 2, 4, and 6 may increase in frequency if System storage rises earlier in the year because a greater proportion of the precipitation in the mountains is expected to fall as rain. Conversely, early evacuation of System

storage coupled with more frequent droughts in summer could result in conditions that result in less frequent flow releases under Alternative 5. However, the frequency of a completed flow release under Alternatives 1, 2, 4, and 6 could decrease due to more frequent exceedances of flood targets. Forecasting calendar year runoff could become less accurate because forecasting runoff based on precipitation may become much more difficult than forecasting runoff based on snow water equivalent. In addition, climate change could result in lower service levels in the second half of the navigation season if runoff falls as rain in late winter while System storage is being evacuated back to 56.1 MAF.

- **Geomorphology**: Higher natural annual flows and a higher number of peak flow events would result in higher sediment erosion rates in the Missouri River watershed under all alternatives. As a result, the mainstem river and tributaries would carry larger volumes of sediment. In addition, rates of degradation, streambank erosion, and aggradation would increase in the inter-reservoir reaches; degradation and streambank erosion would increase in the reach from Gavins Point Dam as far downstream as perhaps to the Platte River confluence, as is currently the case. In addition, geomorphological impacts from the alternatives with releases would mirror the changes in hydrology. Specifically, more frequent and longer flow releases would result in an incremental increase in geomorphological impacts as described in Section 3.2.2.4, Impacts on Geomorphology from the Alternatives; less frequent and shorter flow releases would result in an incremental decrease in geomorphological impacts. Higher air temperatures and higher sporadic flood flows would also affect ice dynamics, resulting in altered flooding patterns from ice dams.
- **Riverine Infrastructure**: Higher natural annual flow rates and more frequent peak flows would increase the impacts (i.e., erosion, wear and tear from frequent overtopping, burial) on river infrastructure under all alternatives. In addition, riverine infrastructure impacts from the action alternatives with releases would also mirror the changes in hydrology. Specifically, more frequent and longer flow releases would result in an incremental increase in riverine infrastructure impacts as described in Section 3.2.2.5, Impacts on Riverine Infrastructure from the Alternatives, less frequent and shorter flow releases would result in an incremental decrease in impacts.

Groundwater: More frequent natural peak flows and more prolonged droughts could result in greater variability in groundwater elevations throughout the year under all alternatives in the floodplain and land adjacent to the river, which could affect wetlands and croplands. In addition, groundwater impacts from the action alternatives with releases would also mirror the changes in hydrology. Specifically, more frequent and longer flow releases would result in an incremental increase in groundwater impacts as described in Section 0, under any of the alternatives.

- Impacts on Groundwater from the Alternatives, less frequent and shorter flow releases would result in an incremental decrease in impacts.

Table 3-5. Summary of Influence of Climate Change on Alternatives

Alternative	Expected Climate Change Variable					
	Increased Air Temperature	**Increased Precipitation and Streamflow**	**Decreased Peak Snow Water Equivalent**	**Earlier Snowmelt Date and Decreased Snow Accumulation Season Duration**	**Increased Sedimentation**	**More Sporadic Floods and Droughts**
1	During the summer, water supply operations could have water quality issues with lower Gavins Point releases if water temperature increases.	May be able to run releases more often because of increased system storage. However, the frequency of a completed release will likely decrease because flood targets will be exceeded more frequently.	Forecasting calendar year runoff has the potential to become less accurate because forecasting runoff based on precipitation is much more difficult than forecasting runoff based on snow water equivalent. Less accurate forecasts may result in an increased risk of overall System impacts (i.e., lower reservoir elevations, lower storage levels) due to setting release magnitudes too high.	May be able to run releases *more* frequently due to System storage rising earlier in the year. Could potentially lower the storage levels for second half of navigation season if the current year's runoff fails as rain in late winter while System storage is being evacuated back to 56.1 MAF.	Decreased System storage may lead to decreased frequency of all releases (assuming release requirements remain the same and sedimentation is not addressed).	Accuracy of downstream forecasting may decrease, resulting in more frequent flood impacts caused by releases. Has a greater potential to affect System storage with releases if more droughts occur.
2	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
3	Same as Alternative 1	Not applicable as there are no new releases	Not applicable as there are no new releases	Could potentially lower the storage levels for second half of navigation season if current year's runoff fails as rain in late winter while System storage is being evacuated back to 56.1 MAF.	Not applicable as there are no new releases	Not applicable as there are no new releases

Alternative	Expected Climate Change Variable					
	Increased Air Temperature	**Increased Precipitation and Streamflow**	**Decreased Peak Snow Water Equivalent**	**Earlier Snowmelt Date and Decreased Snow Accumulation Season Duration**	**Increased Sedimentation**	**More Sporadic Floods and Droughts**
4	During summer, water supply operations could potentially have water quality issues with lower Gavins Point releases if water temperature increases.	May be able to run releases more often because of increased system storage. However, the frequency of a completed release will likely decrease because flood targets will be exceeded more frequently.	Forecasting calendar year runoff has the potential to become less accurate because forecasting runoff based on precipitation is much more difficult than forecasting runoff based on snow water equivalent. Less accurate forecasts may result in an increased risk of overall System impacts (i.e., lower reservoir elevations, lower storage levels) due to setting release magnitudes too high.	May be able to run releases *more* frequently due to System storage rising earlier in the year. Could potentially lower the storage level for second half of navigation season if the current year's runoff fails as rain in late winter while System storage is being evacuated back to 56.1 MAF.	Decreased System storage may lead to decreased frequency of all releases (assuming release requirements remain the same and sedimentation is not addressed).	Accuracy of downstream forecasting may decrease, resulting in more frequent flood impacts caused by releases. Have a greater potential to impact System storage with releases if more droughts occur.
5	Same as Alternative 4	Same as Alternative 4	Same as Alternative 4	May be able to run releases *less* frequently if storage level is lowered for second half of navigation season. Could potentially lower the storage level for second half of navigation season if the current year's runoff fails as rain in late winter while System storage is being evacuated back to 56.1 MAF.	Same as Alternative 4	Same as Alternative 4

Alternative	Expected Climate Change Variable					
	Increased Air Temperature	**Increased Precipitation and Streamflow**	**Decreased Peak Snow Water Equivalent**	**Earlier Snowmelt Date and Decreased Snow Accumulation Season Duration**	**Increased Sedimentation**	**More Sporadic Floods and Droughts**
6	During summer, water supply operations could potentially have water quality issues with lower Gavins Point releases if water temperature increases. The May spawning cue release could be initiated earlier if temperature is used to determine start date.	Same as Alternative 4	Same as Alternative 4	May be able to run releases *more* frequently due to System storage rising earlier in the year. Could potentially lower the storage level for second half of navigation season if the current year's runoff fails as rain in late winter while System storage is being evacuated back to 56.1 MAF.	Same as Alternative 4	Same as Alternative 4

3.2.2.8 Cumulative Impacts

Construction of the Missouri River mainstem reservoir System and the associated dams allows operation with controlled flow releases from the upper river into the lower river to achieve multiple management objectives, as described in this section. Variability in natural hydrologic conditions (precipitation and snowmelt, which include periods of drought and high runoff), and the “rules” governing System operation would continue to dominate the flows in the Missouri River into the future.

Cumulative actions that affect geomorphology and the amount of sediment transport in the river include the construction of system dams that are capturing sediment transported into their reservoirs. Sediment capture has resulted in riverbed degradation downstream of dams as sediment is not resupplied from upstream sources. In the upper river, the sediment eroded from the channel and from streambanks deposits upstream of the next downstream reservoir, resulting in aggradation. Downstream of Gavins Point Dam, eroded sediment is transported through the channelized lower river. Degradation and aggradation impacts would continue.

Past, present, and reasonably foreseeable future actions that would affect riverine infrastructure, such as system-controlled flows and floodplain development including agricultural operations would continue to have adverse impacts on riverine infrastructure. These impacts would require continuous maintenance and potentially new construction. Locally these efforts may vary to accommodate other programs and actions, such as the NPS MNRR Management Actions and would depend in part on hydrologic conditions and the condition of individual infrastructure components.

Natural and system-driven flow variability that affects river stage and the extent of floodplain inundation would continue to be the primary driver of groundwater elevations in the floodplain of the Missouri River. However, other actions and programs, such as construction of levees, floodplain development, and withdrawals for agriculture, municipal, and industrial uses could result in cumulative impacts of the groundwater elevation locally. Programs that provide habitat development including wetlands, such as USFWS Partners for Fish and Wildlife Program and the NPS MNRR Management Actions, could allow inundation and a source of hydrology to groundwater.

Impacts under Alternative 1 from ESH construction and channel reconfiguration for creation of early life stage pallid habitat would result in short-term negligible to small benefits through the resuspension of finer-grained sediment in the water column or mobilization of bedload into the thalweg to be carried downstream by the river.

When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts associated with Alternative 1 would continue to be large, adverse, and long-term natural variability in hydrologic conditions and actions that contribute to bed degradation and aggradation. The continued implementation of Alternative 1 would overall provide a small to negligible contribution to these cumulative impacts.

Under Alternative 2, spawning cue releases and low summer flows would modify flows to some extent, and would overall have small adverse impacts to sediment transport processes, riverine infrastructure, and groundwater elevations relative to Alternative 1. These impacts would be due to changes in reservoir elevations and shoreline erosion in the upper three reservoirs and degradation and aggradation in the inter-reservoir reaches along the upper river and the Gavins Point Dam to Ponca, Nebraska reach. However, locally these impacts could be large. ESH

construction under Alternative 2 would be substantially greater than under Alternative 1 and could affect local and regional flow patterns in the river resulting in lateral shifts of the river channel, bank erosion, and increased rates of degradation and aggradation. Low summer flows could require additional localized dredging in the lower river to maintain the navigation channel. When combined with other past, present, and reasonably foreseeable future actions, cumulative impacts of Alternative 2 would be large and adverse, although Alternative 2 would provide a negligible contribution to cumulative impacts. However, locally impacts could be large as a result of the substantial amount of ESH construction.

Under Alternative 3, the absence of the spawning cue release pulses in March and May and the larger ESH construction relative to Alternative 1 would have negligible cumulative impacts. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 3 would be similar to Alternative 1. Implementation of Alternative 3 would have a negligible contribution to these cumulative impacts.

Under Alternative 4, the spring release would decrease the elevations of Lake Sakakawea and Lake Oahe by several feet. The length of storage recovery and extent of reduction in flow following a spring release would vary in different years depending on natural hydrologic conditions. Additional rates of degradation and streambank erosion during flow releases could be higher relative to Alternative 1. There would also be additional aggradation in the deltas of Lake Oahe and Lewis and Clark Lake. Alternative 4 would have small to negligible temporary and long-term impacts. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 4 would large and adverse, although the contribution of Alternative 4 would be small to negligible, although impacts could be large locally.

The impacts of Alternative 5 would be similar to those described for Alternative 4. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 5 large and adverse, although the contribution of Alternative 5 would be small to negligible, although impacts could be large locally.

Under Alternative 6, the impacts would be similar to those described under Alternative 4, except the spawning cue releases would occur as two pulses (March and May) rather than as a single longer release in the spring. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 6 large and adverse, although the contribution of Alternative 6 would be small to negligible, although impacts could be large locally.

3.3 Pallid Sturgeon

3.3.1 Affected Environment

Pallid sturgeon (*Scaphirhynchus albus*) are large, long-lived benthic (i.e., bottom dwelling) fish that inhabit the turbid, fast-flowing rivers of the Missouri and Mississippi River basins. They have physical features adapted to life in turbid fast-flowing rivers such as a flattened shovel-shaped snout; a long, slender, and completely armored body; fleshy barbels; and a protrusible mouth (i.e., capable of being extended and withdrawn from its natural position) that supplement their small eyes in detecting and capturing food (Figure 3-20). Pallid sturgeon are similar in appearance to the more common shovelnose sturgeon (*Scaphirhynchus platorynchus*) (Figure 3-20). The range of each species overlaps in portions of the Missouri and Mississippi River basins (USFWS 2014). In general, mature pallid sturgeon attain larger sizes than shovelnose sturgeon and have longer outer barbels and shorter inner barbels (USFWS 2014).

The primary sources of information for this section are the most recent publications from two USACE-funded efforts: the Missouri River Pallid Sturgeon Effects Analysis (Jacobson et al. 2016b) and the Comprehensive Sturgeon Research Project (DeLonay et al. 2016). The U.S. Geological Survey (USGS) led both efforts in collaboration with other resource agencies. This section focuses on the aspects of pallid sturgeon life history and biology that are most likely to be affected by the plan alternatives are the focus of this section, including actions to achieve recruitment of age-0 pallid sturgeon into the population.

Photo courtesy USGS; inset photo courtesy Nebraska Game and Parks Commission

Figure 3-20. Shovelnose Sturgeon (left) and Pallid Sturgeon (right)

3.3.1.1 Population Status and Distribution

The pallid sturgeon was listed as endangered under the Endangered Species Act (ESA) on September 6, 1990 (55 Federal Regulation 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 under the Pallid Sturgeon Conservation Augmentation Program (PSCAP) (USFWS 2014). If stocking were to cease, pallid sturgeon would face local extirpation in several reaches of the Missouri River (USFWS 2014).

Jacobson et al. (2016b) describe the natural geographic range of the pallid sturgeon to include the Mississippi and Missouri River basins in which turbid fast-flowing waters flow over predominately sandy substrate. This range includes the Yellowstone and Missouri Rivers downstream to the confluence with the Mississippi River and the Mississippi River from Keokuk, Iowa, to the Gulf of Mexico (including the Atchafalaya River distributary). Also included are lower parts of some Missouri River tributaries, including the Milk River in Montana, Niobrara, and Platte Rivers in Nebraska, Big Sioux River in Iowa, Kansas River in Kansas, and Grand and Osage Rivers in Missouri (Figure 3-21).

Since listing in 1990, wild pallid sturgeon have been documented in the following areas (Figure 3-21) (USFWS 2014):

- In the Missouri River between Fort Benton and the headwaters of Fort Peck Reservoir, Montana;
- Downstream from Fort Peck Dam, Montana to the headwaters of Lake Sakakawea, North Dakota;
- Downstream from Garrison Dam, North Dakota to the headwaters of Lake Oahe, South Dakota;
- From Oahe Dam downstream to within Lake Sharpe, South Dakota;
- Between Fort Randall and Gavins Point Dams, South Dakota and Nebraska;
- Downstream from Gavins Point Dam to St. Louis, Missouri;
- In the lower Milk and Yellowstone Rivers, Montana and North Dakota;
- In the lower Big Sioux River, South Dakota;
- In the lower Platte River, Nebraska;
- In the lower Niobrara River, Nebraska; and,
- In the lower Kansas River, Kansas

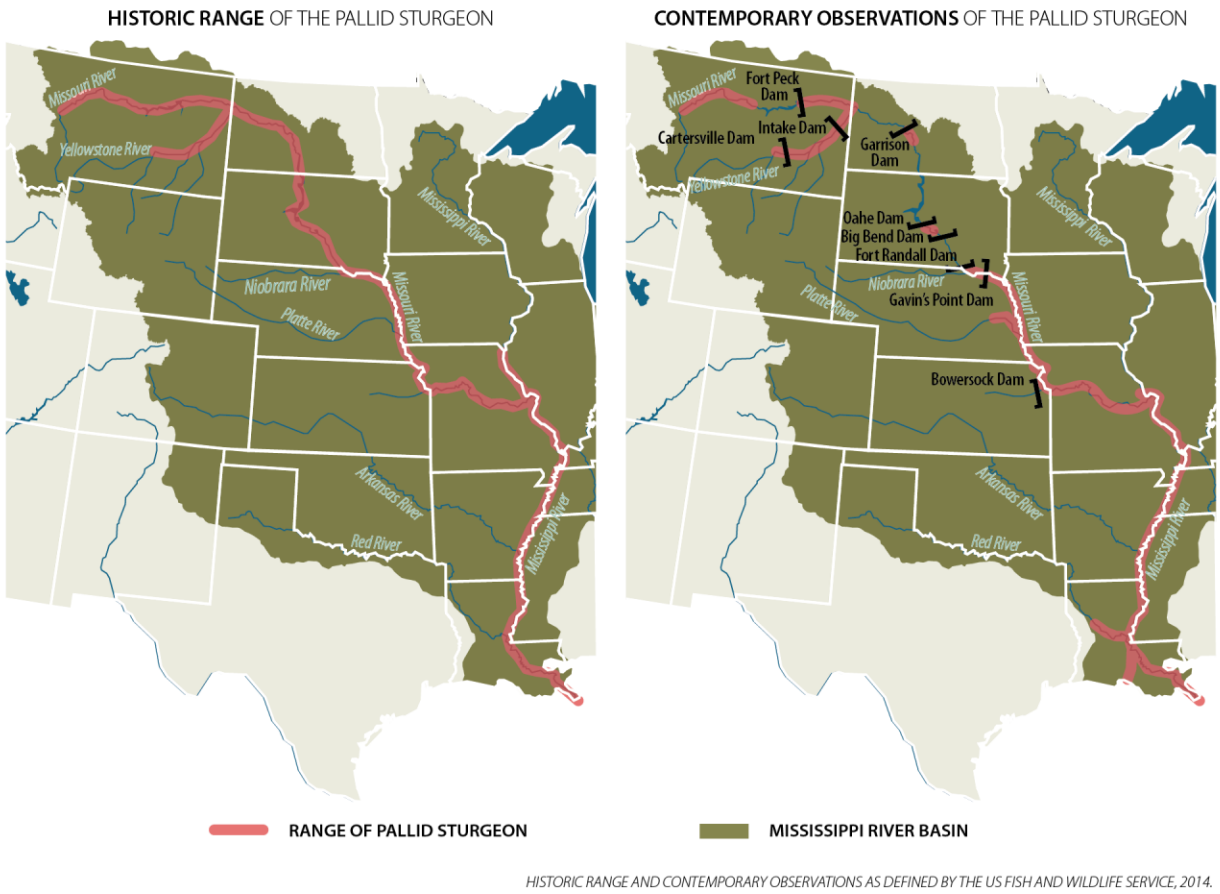


Figure 3-21. Pallid Sturgeon Natural Geographic Distribution (A) and Current Distribution (B)

The following summary of current pallid sturgeon population estimates comes from Jacobson et al. (2016b). Duffy et al. (1996) summarized the estimates of various studies, both published and unpublished, which suggests as few as 6,000 or as many as 12,000 wild pallid sturgeon existed throughout their natural geographic range. Estimates from mark-recapture studies on inter-reservoir populations indicate that the population between Fort Peck and Garrison Dams may range from 125 to 158 wild adults (Jaeger et al. 2009, Braaten et al. 2009). A 1995 survey estimated 45 wild adult pallid sturgeon existed in the river upstream from Fort Peck Lake; however, only three wild pallid sturgeon were collected in this location from 2007 to 2013 (USFWS 2014). Steffensen et al. (2012) estimated that the wild population of the lower Missouri River downstream from Gavins Point Dam was 5,991 pallid sturgeon in 2012. Steffensen et al. (2012) quantified a population estimate for a reach below the confluence of the Platte and Missouri rivers, a reach where catch rates of pallid sturgeon were relatively high. The annual population estimates ranged from 5.4 to 8.9 fish / river kilometer (rkm) for wild pallid sturgeon and 28.6 to 32.3 fish / rkm for hatchery-reared pallid sturgeon. Winders and Steffensen (2014) developed similar population estimates for a reach of the Missouri River downstream of Kansas City, Missouri. The annual population estimates of pallid sturgeon varied from 6.1 to 11.1 fish/rkm, of which known hatchery-origin pallid sturgeon (5.5 to 10.2 fish/rkm) were much more abundant than those of wild origin (0.6 to 0.9 fish/rkm) (Winders and Steffensen 2014). Steffensen et al. (2013) indicated that the population seems to be stable because of

supplemental stocking by the PSCAP but remains neither self-sustaining nor viable. The estimates for the middle Mississippi River (i.e., mouth of the Missouri River to the confluence with the Ohio River) suggest a population of 1,600 to 4,900 pallid sturgeon (Garvey et al. 2009).

The USFWS (2014) defines four pallid sturgeon recovery management units, three of which fall all or partly within the geographic scope of the MRRP. The Great Plains Management Unit is defined as the Great Falls of the Missouri River, Montana to Fort Randall Dam, South Dakota, and includes important tributaries like the Yellowstone River, as well as the Marias and Milk rivers. The portion of the management unit from Fort Peck dam to Fort Randall Dam, and the Yellowstone River from Intake, Montana to the confluence with Missouri River fall within the geographic scope of the MRRP. All of the Central Lowlands Management Unit (Fort Randall Dam to the confluence with the Grand River) falls within the geographic scope of the MRRP. The Interior Highlands Management Unit is defined as the Missouri River from the confluence of the Grand River to the confluence of the Mississippi River, as well as the Mississippi River from Keokuk, Iowa to the confluence of the Ohio and Mississippi rivers. Only the Missouri River portion of the Interior Highlands Management Unit falls within the geographic scope of the MRRP. 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 of four management units for two generations (20–30 years). In this context, a self-sustaining population is described as a spawning population that results in sufficient recruitment of naturally produced pallid sturgeon into the adult population at levels necessary to maintain a genetically diverse, wild adult population in the absence of artificial population augmentation (USFWS 2014).

3.3.1.2 Reproduction and Recruitment

The following discussion of pallid sturgeon reproduction and recruitment is organized by life stages as presented in Jacobson et al. (2016b). These stages are similar to those described by Wildhaber et al. (2011) and documented in the pallid sturgeon conceptual ecological models (CEMs) (Jacobson et al. 2015). Table 3-6 summarizes the seven life stages.

Table 3-6. Pallid Sturgeon Life Stages

Life Stage	Description
Embryo	Period from fertilization to hatching (5–8 days)
Free embryo	Period from hatching until the larval fish begins feeding (8–12 days post-hatch)
Exogenously feeding larvae and age-0	Period from full development of fin rays during the winter until June 1 of the following year. (June 1 was selected as a fixed time to demarcate age-0 stages compared to age 1+ fish.)
Juvenile	Period of pallid sturgeon sexual immaturity; a fish can remain in this stage until age-9.
Spawning adult	This stage includes juvenile fish that have become sexually mature and are ready to spawn and adult fish that have already spawned and are ready to spawn again.
Post-spawn adult	An adult fish that has released its gametes.
Recrudescent adult	A post-spawn adult fish that is replenishing gametes. The fish may remain in this state for as many as 4 years.

Source: Jacobson et al. 2016b

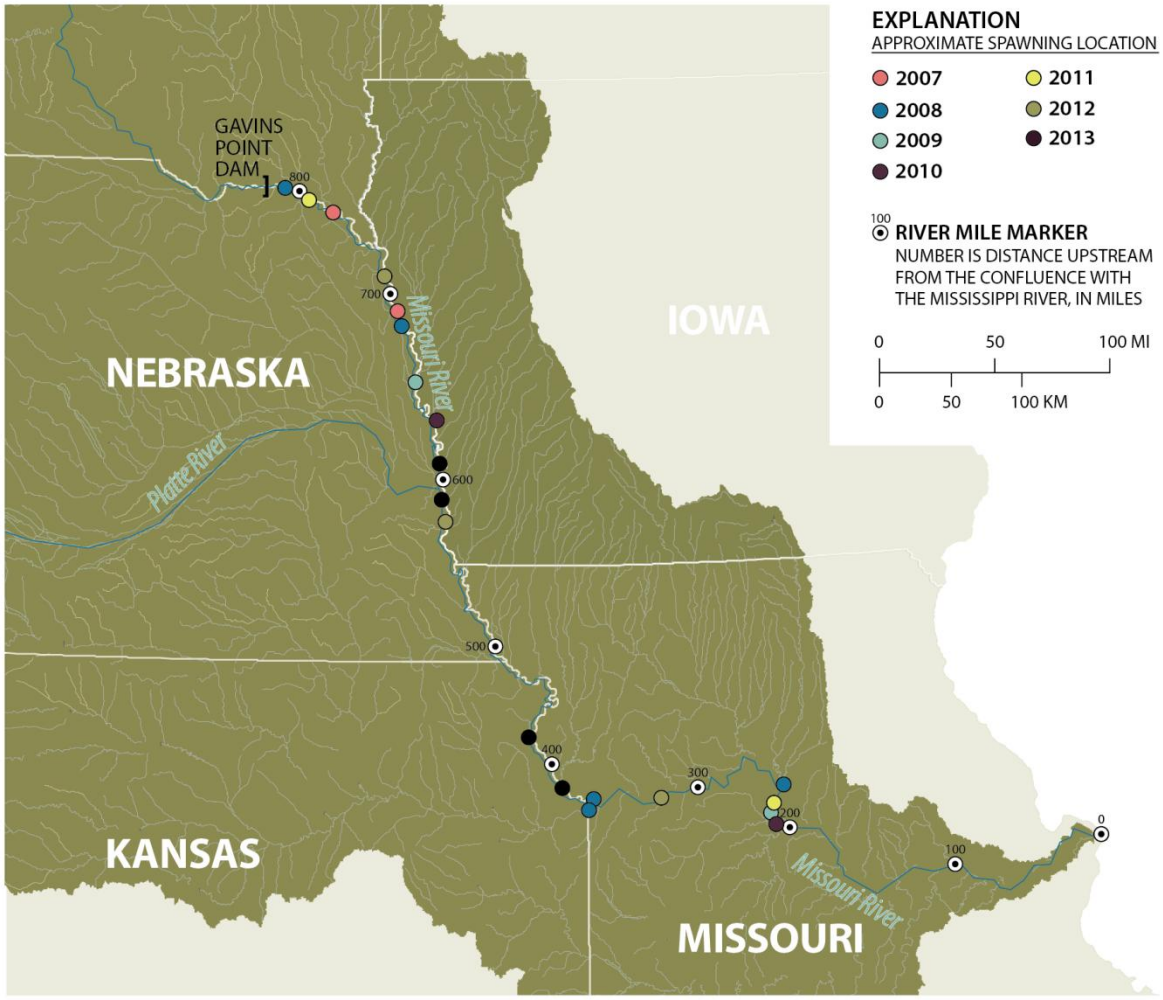
Adult Life Stage

Pallid sturgeon can be long-lived, with females reaching sexual maturity later than males (Keenlyne and Jenkins 1993). Based on information collected from wild fish, the estimated age at first reproduction was 15 to 20 years for females and approximately 5 to 7 years for males (Keenlyne and Jenkins 1993). Minimum age-at-sexual maturity for known-aged hatchery-reared fish, was age-9 for females and age-7 for males (Steffensen 2012). Age at first reproduction can vary between hatchery-reared and wild fish and depends on local conditions (USFWS 2014).

Pallid sturgeon generally spawn from late April through May in the lower Missouri River and mid-June through early July in the upper Missouri River (DeLonay et al. 2016). Reproductively ready pallid sturgeon indicate consistent patterns of upstream migration before spawning. These migration patterns can differ between males and females; male patterns are less regular. It is not currently known if males migrate and select spawning locations in advance of the arrival of females in the lower Missouri River; however, aggregations of males have been documented in the lower Yellowstone River, and these areas of aggregation have coincided with sites where spawning by females has been documented (DeLonay et al. 2016). Mapping of migration pathways found minimum migration distances ranging from 20 to 190 miles. In the lower Missouri River, migrating pallid sturgeon in Nebraska and Iowa avoid very shallow areas and use the range of velocities available to them while avoiding velocities on the low and high ends of the distribution. Migrating pallid sturgeon in Missouri selected shallow places in the channel, and velocities on the low end of the distribution, which indicates selection of migration pathways that optimize energy expenditure (DeLonay et al. 2016).

Telemetry studies of reproductive pallid sturgeon on the lower Missouri River have documented 29 spawning events (Jacobson et al. 2016b) (Figure 3-3). Spawning habitat is discussed later in this section. Spawning has been documented in most reaches of the lower Missouri River, including the channelized portions of the BSNP and the unchannelized reach downstream of Gavins Point Dam (DeLonay et al. 2016). These studies suggest that pallid sturgeon can spawn in a wide range of environmental conditions; however, they do not answer the question of whether spawning is more or less successful in any particular reach (DeLonay et al. 2016).

Pallid sturgeon do not spawn on a 12-month cycle. DeLonay et al. (2016) tracked one male that had a 2-year spawning cycle and six males that had a cycle of longer than 1 year, but total cycle length could not be determined. Of 20 female pallid sturgeon tracked, most had spawning cycles longer than 2 years (DeLonay et al. 2016).



Adapted from DeLonay et al. 2016

Figure 3-22. Documented Pallid Sturgeon Spawning Sites in the Lower Missouri River (2007–2014)

Embryo Life Stage

An embryo is a developing fish within the egg membrane; this life stage covers the period from fertilization to hatching. The embryo life stage for pallid sturgeon usually lasts 5 to 8 days depending on water temperature (DeLonay et al. 2016). Most of what is known about habitat requirements for embryos is extrapolated from laboratory studies. Naturally spawned pallid sturgeon eggs become sticky or adhesive 1 to 3 minutes after fertilization (Dettlaff et al. 1993) and presumably fall through the water column to affix to solid substrate such as rock (DeLonay et al. 2016). The relative importance of turbidity for the deposition, fertilization, and hatch of pallid sturgeon embryos is unknown (DeLonay et al. 2016). It is also unknown if predation is a threat to pallid sturgeon embryos (DeLonay et al. 2016). Suitable habitat for embryos is included in the spawning habitat discussion later in this section.

Free Embryo Life Stage

A free embryo is a developing fish that no longer resides within the egg membrane. This life stage for pallid sturgeon lasts 8 to 12 days post-hatch and covers the period from hatch until the larval fish begins feeding (DeLonay et al. 2016). Available information on the pallid sturgeon free embryo life stage primarily comes from laboratory studies. DeLonay et al. (2016) state these studies and complementary field studies (Braaten et al. 2008, 2012) indicate: (1) pallid sturgeon free embryos drift and disperse downstream at a rate slightly less than mean water column velocity; (2) downstream drift and dispersal occur during day and night; (3) duration of the free embryo drift period depends on water temperature and rate of development; and (4) free embryos will drift and disperse several hundred kilometers during development into exogenously (i.e., external) feeding larvae, with total drift distance a function of water temperature, development rate, and velocity conditions in the river channel. As discussed in Chapter 2.0, hypotheses differ regarding whether free embryos initiate drift immediately after hatch or spend one to several days hiding in interstitial spaces in substrate. Drifting free embryos use up their yolk sac and develop swimming ability, after which they “settle” into environments conducive to feeding, growth, and survival.

Exogenously Feeding Larvae Life Stage

The larval life stage is a developing fish without a yolk, feeding exogenously (i.e., it has consumed its yolk sac and must now feed externally). The period of transition from endogenous (growing or produced by growth from deep tissue) to exogenous feeding is considered critical because the larvae must find sufficient food of the correct size and type or it will starve. Larval pallid sturgeon have been reported to consume the larvae and pupae of Dipterans (mainly from the family Chironomidae (i.e., midges) and Ephemeroptera nymphs (i.e., mayflies)) (DeLonay et al. 2016).

Juvenile Life Stage

The juvenile life stage consists of sexually immature fish and lasts until the fish enters its first reproductive cycle. During this period, the juvenile pallid shifts its diet from insects to fish (Gerrity et al. 2006; Grohs et al. 2009). Observed conditions where pallid sturgeon have been found as part of the Pallid Sturgeon Population Assessment Program (PSPAP) between 2003 and 2010 provide notable differences between juveniles and adults that suggest differences in habitat use (Welker and Drobish 2010). During late spring through fall, juveniles found in the Missouri River above Gavins Point Dam tended to be collected in cooler water temperatures than adults, with the reverse pattern observed below Gavins Point Dam. However, during this same season, juveniles tended to be collected in shallower, slower water than adults throughout the river. Throughout the river, during late fall through early spring, juveniles tended to be collected in warmer water than adults, with depth differences still present but not as dramatic as observed during late spring through fall and with no obvious differences in velocity (DeLonay et al. 2016).

Diet composition plays a large role in the growth of juvenile pallid sturgeon to adults (Grohs et al. 2009), with chironomids (Order: Diptera) and mayflies (Order: Ephemeroptera) serving as important components of early juvenile diets (Sechler 2010; Sechler et al. 2013). Pallid sturgeon diets shift from macroinvertebrates to fish as they grow. Of the food eaten by juvenile pallid sturgeon between 350 and 500 mm fork length, 57 percent was fish, whereas fish made up 90 percent of the diets of juvenile pallid sturgeon longer than 500 mm fork length (Gerrity et al. 2006; Grohs et al. 2009). Isotope analyses of pectoral spines support gut analyses and indicate

that the diet shift of juvenile pallid sturgeon from invertebrates to fish likely occurs at or before 500 mm fork length–well before pallid sturgeon reach reproductive maturity (French 2010). Limited prey sources increase mortality and may suppress growth in surviving juveniles (Deng et al. 2003; DeLonay et al. 2009). No clear relationship has been documented between abiotic factors (e.g., water temperature) and pallid sturgeon recruitment, but early diet and growth are hypothesized to affect recruitment into adult spawning populations (DeLonay et al. 2009; Sechler 2010).

3.3.1.3 Pallid Sturgeon Functional Habitat

Jacobson et al. (2016b) defined pallid sturgeon functional habitats based on a synthesis of the best available science. Functional habitat definitions attempt to quantify the broad continuum of habitat conditions experienced by pallid sturgeon into relatively few habitat classes that relate to important biological and population responses. Definitions of spawning and interception habitats are considered especially tentative. The following descriptions are taken from Jacobson et al (2016b).

Spawning Habitat

Although pallid sturgeon spawning has been documented in the lower Missouri River, evidence of successful reproduction if evaluated in terms of successful fertilization, incubation, and hatch of free embryos is limited. Since 2011, six wild pallid sturgeon larvae have been collected in the lower Missouri River below Gavins Point Dam. For successful hatch to take place, hydraulics and substrate must be conducive first to attraction and aggregation of reproductive adults, followed by egg and milt release, fertilization, and deposition of eggs in a protected environment. Habitats quantified at spawning sites on the lower river indicate that females release their eggs in the deepest, fastest, and most turbulent parts of the channel, typically on revetment on outside bends. In previous habitat-modeling studies, these habitats were identified based on hydraulic criteria of convergent flow as cells with unit discharge (discharge per unit width) that were greater than the mean plus 1.5 standard deviation (Jacobson et al. 2009). These criteria mapped fast and highly turbulent areas of the thalweg (navigation channel).

Adhesive eggs are generally associated with spawning that occurs over coarse, hard substrate. However, it is unknown whether fertilized eggs end up in interstices of the substrate or on the surface or whether fertilized eggs are at risk of scour or burial by transporting sand. Confirmed spawning sites on the Yellowstone River, which serve as a natural reference condition, have recently been documented and may serve to improve the understanding of what occurs with the fertilized eggs. Spawning sites on the Yellowstone River are shallower than the lower Missouri River (with a mean depth of 3.3 m compared to 6.6 m) and slower (with a mean current velocity of 1.1 m/s compared to 1.4 m/s).

Interception Habitat

A prominent hypothesis for recruitment failure is that newly hatched free embryos are not able to exit the thalweg to transition to first feeding in sufficient numbers before they starve because the river lacks hydraulic conditions that would transport them into supportive channel-margin habitats (i.e., habitats with food and protection that are required on first feeding). This hypothesis recognizes that channelization of the Missouri River has created an extremely efficient hydraulic system for downstream transport compared to the natural system (Jacobson and Galat 2006). The so-called interception habitats, or hydraulic conditions that would intercept the downstream transport of embryos and move them to channel margin habitat, are presently hypothetical. In contrast to many conventional habitat definitions that ascribe attributes to a

polygon or water volume, the interception habitat is hypothesized to be a hydraulic condition related to channel geometry and not necessarily represented as a space or volume. Presently, available information points to a combination of flow expansion and available channel width that creates secondary flow cells with sufficient velocity to transport free embryos out of the navigation channel and into channel-margin areas. One supporting analysis uses sandbar persistence over multiple decades as a metric for physical conditions that would support interception and deposition of particles being transported in the thalweg. A statistical model at the bend scale indicates channel width and the standard deviation of constricted width are dominant explanatory variables for location and size of sandbars. However, the most direct biological dependent variable available (catch per unit effort [CPUE] of age-0 *Scaphirhynchus* spp. from the PSPAP) does not correlate well with the longitudinal distribution of these physical variables, and the variables used to explain the distribution of sand do a poor job of predicting CPUE. Within the context of uncertainties about CPUE as a reliable metric, the longitudinal distribution of CPUE suggests that physical conditions, measured as channel width and contraction/expansion of flow, may be *necessary* to intercept drifting free embryos but are not *sufficient*. The distribution may be strongly controlled by the origin, rate of drift, and rate of development of the free embryos superimposed on the physical conditions promoting interception and retention. Predictive modeling of interception habitats may require the ability to inventory secondary currents and recirculation along the river and evaluate how interception conditions vary with discharge.

Food-Producing Habitat

Another hypothesis for recruitment failure is that free embryos cannot find proper food items when they need to transition to exogenous feeding. Presently available data document that the diets of age-0 pallid sturgeon larvae are dominated by Chironomidae larvae (Sechler et al. 2012; Harrison et al. 2014). Chironomidae are preferentially associated with stable, fine sediment in low-velocity habitats (Poulton et al. 2003). In a detailed study of age-0 *Scaphirhynchus* diets on the Mississippi River, six Chironomidae taxa made up 74 percent of the fish diets, and all were characterized as sand-dwelling, burrowing species. Using a simple entrainment criterion for fine sand, food-producing habitats were characterized by Jacobson et al. (2016b) as velocities less than 0.08 m/s.

Foraging Habitat

Foraging habitat is conceptualized as the hydraulic conditions conducive to foraging for food items (i.e., where velocities are sufficient to bring drifting invertebrates from food-producing source areas to the age-0 pallid sturgeon but where velocities are not so high as to require too much energy expenditure). Conceptually, this describes a zone on the channel margin between low-velocity water adjacent to the banks and the thalweg where drifting food is concentrated, yet velocities are not too high to preclude holding in the current. Empirical data indicate that age-0 pallid sturgeon are found in waters with a velocity of about 0.5–0.7 m/s and a depth of 1–3 m (Ridenour et al. 2011).

3.3.1.4 MRRP Management Actions

The USACE MRRP has been implementing actions to comply with the reasonable and prudent alternative (RPA) included in the 2003 Amended BiOp (USFWS 2003). Chapter 1.0 describes the 2000 BiOp and 2003 amendment process in more detail. This section describes the actions implemented that are part of the existing condition, which includes constructing shallow water habitat (SWH), implementing the spring plenary pulse, and supporting the PSCAP.

Shallow Water Habitat

The BiOp RPA stipulates the creation of SWH in the lower Missouri River from Ponca, Nebraska, to the mouth to achieve a density of 20 to 30 acres per river mile. According to the BiOp, SWH may be restored through flow management, increasing the top width of the channel (top-width widening), restoring chutes and side channels, manipulating summer flows, or combinations thereof (USFWS 2000, 2003). SWH refers to mainstem and off-channel areas of the Missouri River where water is relatively shallow and current velocities are relatively low. The 2000 BiOp and amended 2003 BiOp set forth a quantitative definition of SWH as areas where water depth between mid-July and mid-August is greater than 0 but less than 5 ft (0–1.5 m) and where flow velocity is between 0 and 2 ft/s (0–0.6 m/s) (USFWS 2000, 2003). Additional descriptors of SWH attributes were provided in a USFWS letter to USACE dated June 29, 2009. The letter states that SWH "include[s] side channels, backwaters, depositional sandbars detached from the bank, and low lying depositional areas adjacent to shorelines. Key physical components of SWH are their dynamic nature with depositional and erosive areas, predominance of shallow depths intermixed with deeper holes and secondary side channels, lower velocities, and high water temperatures than main channel habitats."

SWH is thought to benefit young pallid sturgeon and small-bodied fishes in multiple ways when synchronized with life-stage needs. SWH is hypothesized to benefit pallid sturgeon by slowing larval drift and increasing retention of larval fish by providing nursery areas for larval and young-of-year fishes and by increasing production and retention of food sources in these areas of the Missouri River (USACE and USFWS 2012).

USACE prepared a SWH Accounting Report in 2014 to document its compliance with SWH acreage goals stated in the BiOp (Table 3-7).

Table 3-7. Existing Shallow Water Habitat Acres

River Segment	Segment Length (RM)	2014 Acres/mile	2014 Total Acres	Additional Identified Acres*	Total Existing SWH Acres
Ponca to Sioux City	18	6.6	120	0	120
Sioux City to Platte River	140	12.1	1,682	97	1,779
Platte River to Kansas River	228	11.2	2,560	199	2,759
Kansas River to Osage River	237	15.7	3,710	93	3,803
Osage River to Mississippi River	130	25.0	3,253	118	3,371
		Total:	11,325	507	11,832

* Accounts for assumed acreages from chutes that not included in the 2014 SWH Accounting Report and modifications to existing chutes and top-width widening projects as a result of 2011 flood damages.

Spawning Cue Release

As discussed in Chapter 1.0, a bimodal Gavins Point spring pulse plan was developed in 2005, and the technical criteria (operating “rules”) for implementing the pulse were incorporated into the Master Manual in 2006. However, because the Missouri River basin has experienced either drought conditions or excess water almost every year since 2006, a bimodal spring pulse has not been conducted. A single intentional spring pulse release to enhance reproduction of pallid sturgeon occurred in May 2006, March 2008, and May 2009. The May 2006 pulse release peaked at 25,000 cfs, the March 2008 release peaked at 18,000 cfs, and the May 2009 release peaked at 23,000 cfs.

The intentional spring pulses in the upstream reach of the lower Missouri River were small relative to the uncontrolled flow pulses in the downstream reach. In all years, the downstream section (i.e., Boonville, Missouri stream gage) had substantial spring pulses, at least four times the discharge of the intentional releases. Pulses of 200,000 cfs or more occurred in all years except 2006 and 2012, which were the two driest years of the period on the lower Missouri River. The peak spring pulse discharge in 2006 was 96,000 cfs on May 3 and the peak in 2012 was 133,000 cfs on April 18.

Propagation and Augmentation

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. Federal and state hatcheries involved with propagation of Missouri River pallid sturgeon stocked a combined 24,309 fingerling and yearling-sized pallid sturgeon from the 2013 and 2014 year classes into resource priority management areas (RPMAs) 1–4 during 2014. Monitoring data collected through the PSPAP indicate that stocked pallid sturgeon are surviving, growing, and reaching a size and age that is capable of spawning. Recent survival estimates for hatchery fish stocked into the Missouri River show relatively high rates of survival (Hadley and Rotella 2009; Rotella 2012; Steffensen et al. 2010) that are similar to other sturgeon species (Ireland et al. 2002). Since 2001, more than 290,000 yearling equivalent pallid sturgeon have been stocked into the Missouri River. Survival rates for hatchery pallid sturgeon stocked into the Missouri River (1994–2007) have been estimated as follows: age-0 = 0.051; age-1 = 0.686; and age-2> = 0.922 (Steffensen et al. 2010). Continued monitoring of the stocked population will determine how these fish contribute to the next generation of pallid sturgeon. As previously mentioned, the USFWS (2014) credits stocking of pallid sturgeon with stabilizing the population. A Pallid Sturgeon Basin-wide Stocking and Augmentation Plan is being developed by the Pallid Sturgeon Recovery Team and participating federal agencies due to concerns related to fish health/disease, genetics, stocking size, numbers/carrying capacity, and stocking practices.

3.3.2 Environmental Consequences

This section considers the potential impacts of each alternative on the Missouri River pallid sturgeon population with special emphasis on the potential to increase survival of age-0 pallid sturgeon and increase recruitment.

3.3.2.1 Impacts Assessment Methodology

A comprehensive pallid sturgeon population model relating the effects of all potential management actions to population dynamics is not currently available, although the framework

of such a model has been developed (Jacobson et al. 2016). As a result, the analysis of potential impacts on pallid sturgeon is based on review of available scientific literature discussing key life history processes and population dynamics, conceptual ecological models, diet, habitat, movements, recruitment, spawning, and extensive information from the effects analysis for pallid sturgeon.

The geographic scope of analysis for pallid sturgeon populations is the upper and lower Missouri River. The upper river includes the area from Fort Peck Dam downstream to the headwaters of Lake Sakakawea plus accessible parts of the Yellowstone River, and the lower river includes the Missouri River from Gavins Point Dam downstream to the confluence with the Mississippi River.

Alternatives were evaluated to determine potential impacts anticipated during and after implementation of each management action. Direct and indirect, adverse and beneficial impacts were determined. The duration and intensity of impacts are described using the guidelines described in Section 3.1, Introduction.

The No Action Alternative is considered the baseline against which the other alternatives are measured. Under the No Action Alternative, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, the No Action Alternative does 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.

3.3.2.2 Summary of Environmental Consequences

Table 3-8 summarizes the impacts of each alternative on pallid sturgeon. The one-time spawning cue test (Level 2) release that might 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.

Table 3-8. Environmental Consequences Relative to Pallid Sturgeon

Alternative	Impacts on Pallid Sturgeon
Management Actions Common to All Alternatives	• Negligible impacts from potential herbicide exposure associated with management of ESH for piping plover and least tern. • No impacts from predator management or human restriction measures associated with management of ESH for piping plover and least tern. • Long-term, beneficial impacts from propagation and augmentation of pallid sturgeon as a result of continued population stabilization. • Long-term, indirect beneficial impacts from PSPAP because critical information would be provided for adaptive management. • Long-term and localized, indirect benefits from habitat development and management on MRRP lands as a result of potential increases in productivity.

Alternative	Impacts on Pallid Sturgeon
Alternative 1	• Negligible impacts from ESH and SWH construction activities. • Possible long-term benefits from SWH construction, although it is uncertain how beneficial SWH would be to age-0 pallid sturgeon compared to other habitats or management actions. • No impacts from spawning cue release. • Limited beneficial impacts from adaptive management.
Alternative 2	• Negligible impacts from ESH construction activities. • Negligible impacts from SWH construction activities. Possible long-term benefits, although it is uncertain how beneficial SWH would be to age-0 pallid sturgeon compared to other habitats or management actions. • Possible beneficial impacts from spawning cue release and low summer flow. Evidence is lacking to confirm or quantify the level of benefit. • Continued relatively small benefits from floodplain connectivity. • Limited, beneficial impacts from adaptive management.
Alternative 3	• Negligible impacts from ESH and interception and rearing complex (IRC) construction activities. • Possible long-term, beneficial impacts from construction of spawning sites. • Possible long-term benefits from IRC construction. It is uncertain how beneficial IRC would be to age-0 pallid sturgeon. • Long-term, beneficial impacts from active adaptive management.
Alternative 4	• Negligible impacts from ESH and IRC construction activities. • Possible long-term, beneficial impacts from construction of spawning sites. • Possible long-term benefits from IRC construction, although it is uncertain how beneficial IRC would be to age-0 pallid sturgeon. • Negligible impact anticipated from the spring ESH creating releases. • Long-term, beneficial impacts from active adaptive management.
Alternative 5	• Negligible impacts from ESH and IRC construction activities. • Possible long-term, beneficial impacts from construction of spawning sites. • Possible long-term benefits from IRC construction, although it is uncertain how beneficial IRC would be to age-0 pallid sturgeon. • No impact anticipated from fall ESH creating releases. • Long-term, beneficial impacts from active adaptive management.
Alternative 6	• Negligible impacts from ESH and IRC construction activities. • Possible long-term, beneficial impacts from construction of spawning sites. • Possible long-term benefits from IRC construction, although it is uncertain how beneficial IRC would be to age-0 pallid sturgeon. • Possible beneficial impacts from spawning cue release. Evidence is lacking to confirm or quantify the level of benefit. • Long-term, beneficial impacts from active adaptive management.

3.3.2.3 Impacts from Management Actions Common to All Alternatives

Vegetation Management, Predator Management, and Human Restriction Measures

Herbicides could potentially enter the substrate during ESH management operations for piping plovers and least terns. U.S. Environmental Protection Agency (EPA)-approved herbicides for aquatic use would be applied. Studies on the effects of certain herbicides (e.g., glyphosate and imazapyr) on fish species (e.g., salmonid species, trout, flagfish, freshwater fish) have found that when used at recommended rates, they pose little or no risk of acute toxicity or are practically non-toxic (Giuseppe et al. 2006; WSDA 2003). While no studies have been

conducted specifically on the impacts of glyphosate or imazapyr on pallid sturgeon, impacts are expected to be similar to those described on other fish species discussed in scientific literature. The risk of overspraying would be minimized by use of an all-terrain vehicle or backpack sprayer or, if the area involved indicated the need for helicopter applications, the risk would be minimized by adjusting boom and droplet size using a GPS to ensure targeted application and restricting application during certain wind conditions. Impacts on pallid sturgeon from vegetation management are expected to be negligible.

Predation management actions and human restriction measures to benefit piping plover and least tern would have no impact on pallid sturgeon.

Propagation and Augmentation

As noted in Chapter 2.0, USACE supports the PSCAP with annual funding. Decisions on hatchery operations and protocols for propagation and augmentation are within the purview of the USFWS and the Pallid Sturgeon Recovery Team's Propagation Committee. Implementation of the PSCAP to date has stabilized the pallid sturgeon population in the Missouri River (USFWS 2014); however, the population is not considered self-sustaining. The most recent revision of the Pallid Sturgeon Recovery Plan identifies one of the primary strategies as "use artificial propagation to prevent local extirpation within management units where recruitment failure is occurring." It is assumed that any future adjustments to the PSCAP would be in accordance with that strategy. Therefore, continued implementation of the PSCAP is anticipated to have long-term, beneficial impacts on the pallid sturgeon population.

Pallid Sturgeon Population Assessment Project

USACE has been implementing the PSPAP as part of current program implementation. The PSPAP has provided important, long-term data on metrics, including population trends, survival, movement, distribution, and habitat use by pallid sturgeon and other target fishes. The PSPAP collects population-level data (size, growth, survival, and distribution) that would be used to parameterize stage-based population models for pallid sturgeon. Although any activity that includes the capture and handling of pallid sturgeon may stress individuals, these activities would result in negligible impacts on the population. The PSPAP is a critical management action to support adaptive management of pallid sturgeon under all plan alternatives and represents a long-term, indirect beneficial impact on the pallid sturgeon population. The Science and Adaptive Management Plan (AM Plan) proposes some improvements to the current PSPAP.

Monitoring and Evaluation of Recruitment

The MRRMP-EIS assumes that improvements to fish passage at Intake Diversion Dam would occur. USACE support of monitoring and evaluation of fish passage at Intake Diversion Dam would focus on testing the response of improved passage on adult pallid sturgeon spawning in the upper Yellowstone River and drift of free embryos downstream to reduce the uncertainties associated with management hypotheses. Incorporating bypass at Intake into the AM Plan sets up a comprehensive strategy to learn from that action as well as decrease relevant uncertainties on both the Missouri and Yellowstone River so that subsequent actions on either system will be informed.

Habitat Development and Land Management on MRRP Lands

Habitat development and land management on MRRP lands acquired to construct early life stage pallid sturgeon habitat would have negligible impacts on pallid sturgeon. Conversion of predominantly agricultural lands to native floodplain habitats may increase localized in-river primary and secondary productivity, which could provide a long-term, indirect benefit for pallid sturgeon. The nature of these benefits would be expected to be proportional to the amount of land acquisition associated with each alternative. Alternative 2 would have potential for the most indirect beneficial impacts from this action, followed by Alternative 1. Alternatives 3-6 would have a similar level of benefit.

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

This section describes impacts on pallid sturgeon from management actions included in Alternative 1 that would be implemented in addition to those described in Section 3.3.2.3, “Impacts from Management Actions Common to All Alternatives.”

Mechanical ESH Construction

The most likely means in which mechanical ESH construction could affect pallid sturgeon would be through entrainment in dredge intakes. Evidence suggests a low risk of entrainment (dredge intake) for fish during dredging operations. Pallid sturgeon did show some risk of entrainment in a laboratory study, largely as a result of the substrate resting behavior they exhibited (Hoover et al. 2005). However, a field study evaluating the potential entrainment of pallid sturgeon by sand mining operations found no entrainment of fish as a result of dredging operations (ERDC 2008). Although the potential for adverse impacts on pallid sturgeon from entrainment cannot be ruled out entirely, studies indicate the risk is low and, as a result, the impact would be negligible.

Mechanical ESH construction could result in temporary increases in turbidity in the area of construction. However, pallid sturgeon are adapted to turbidity levels much greater than which currently exist in these river reaches; therefore, impacts would be considered negligible and increased turbidity could be beneficial to pallid sturgeon.

A low potential for construction-related adverse impacts on pallid sturgeon associated with the magnitude of ESH construction specified under Alternative 1 is anticipated. Avoiding and minimizing impacts on pallid sturgeon from construction activities would be considered during site-specific planning and implementation. Local monitoring data and consultation with state and federal experts knowledgeable of specific sites and habitats important to pallid sturgeon would be used to identify and avoid higher risk areas.

Channel Reconfiguration for Creation of Early Life Stage Habitat

The USFWS BiOp hypothesizes that a lack of slow, shallow water limits pallid sturgeon population growth (USFWS 2000, 2003). Under Alternative 1, USACE would create an additional 4,388 acres of SWH between Ponca, Nebraska, and the mouth of the Missouri River to achieve a SWH target acreage of 20 acres per river mile. The impact analysis assumes that additional SWH would be created through channel widening and off-channel backwaters. Under Alternative 1, the habitat would be constructed to meet the updated SWH definition provided by USFWS.

Several recent studies provide information to better understand habitat use by age-0 *Scaphirhynchus* sturgeon. Local scale analyses (i.e., at the capture site) found that age-0 sturgeon (≤ 109 mm) were often captured at sites that did not meet the SWH definition, particularly for depth (Ridenour et al. 2011; Gosch et al. 2015; Gemeinhardt et al. 2016). Past efforts investigated the effect of SWH construction on fish communities at the river bend scale, finding little to no difference in fish communities among modified and control river bends, but results specific to age-0 sturgeon were not reported (Ridenour et al. 2010; Schapaugh et al. 2010). Gemeinhardt et al. (2016) investigated age-0 sturgeon catch at multiple spatial scales (1 km, 1 bend, 2 bends, 3 bends) using data from the PSPAP and found little to no relationship between the availability of shallow water (< 1.5 m deep) and age-0 sturgeon catch. While Gemeinhardt et al. (2016) used existing long-term monitoring data, Schapaugh et al. (2010) recommended evaluation at a broader scale (e.g., reach-level), and cumulative downstream benefits of SWH were observed in a 32 km reach of the lower Missouri River (Ridenour et al. 2010). However, Gosch et al. (2016) found that the increased availability of shallow water < 1.5 m deep did not yield increased age-0 sturgeon catch at the reach level.

In general, studies to date suggest that age-0 sturgeon do not use shallow water as often as expected; however, shallow water may still be important to their survival. Rare habitats harboring a small percentage of a population can be important if the survival benefit is relatively high. For example, age-0 sturgeon occupying shallow water or using areas with a high availability of shallow water may experience more beneficial conditions (e.g., more abundant food resulting in better condition and survival) relative to individuals found in other habitats (Gemeinhardt et al. 2016). Construction of SWH is anticipated to result in long-term benefits to pallid sturgeon; however, it is uncertain how beneficial SWH would be to age-0 pallid sturgeon compared to other habitats or management actions.

Construction of SWH could temporarily disturb or displace pallid sturgeon in the vicinity, resulting in negligible impacts. The impacts would be site-specific and are not anticipated to affect the lower Missouri River pallid sturgeon population.

Spawning Cue Release

As described in Chapter 2.0 and in the Master Manual (USACE 2006a), a bimodal spawning cue release from Gavins Point Dam would be implemented every year that specified conditions are met. The results of reservoir simulation modeling indicate that the bimodal spawning cue releases would only meet the conditions for implementation once every 8 years. Spawning cue releases from Gavins Point Dam could affect pallid sturgeon in several tributaries downstream from Gavins Point Dam because reproductive sturgeon adults may select the mainstem Missouri River rather than a tributary, depending on the magnitude or quality of cues from other locations. A naturalized flow regime, which includes flow pulses in the spring, could be necessary to cue pallid sturgeon spawning behavior according to the BiOp (USFWS 2000, 2003).

The Pallid Sturgeon Effects Analysis identifies scientific hypotheses linked to benefits of altering the flow regime at Gavins Point Dam. The nature of the release varies by hypothesis; however, all alterations relate to system adjustments to achieve a more “naturalized” hydrograph downstream of Gavins Point Dam (Jacobson et al. 2016b). One hypothesis linked to alteration of the flow regime at Gavins Point Dam asserts that spring flow pulses from Gavins Point Dam would provide aggregation and spawning cues for reproductive pallid sturgeon, increasing the chance that mates will find one another, release their gametes in close proximity to each other, and ultimately result in an increase in fertilized embryos (Jacobson et al. 2016).

Empirical data are ambiguous on behavioral responses of reproductive pallid sturgeon to flow pulses (DeLonay et al. 2009; DeLonay et al. 2016). Reproductive migrations of pallid sturgeon on the lower river have exhibited little evidence of correlation with natural and manipulated flow pulses; however, reproductive migrations of pallid sturgeon on the upper river indicate that fish may select between the upper Missouri and Yellowstone Rivers based on hydrologic cues (discharge characteristics, temperature, turbidity, or a combination of the three). Pallid sturgeon tracking observations near the upper Missouri and Yellowstone Rivers support the hypothesis that sufficiently large flow pulses or larger flow pulses relative to antecedent or adjacent flow may trigger migration and aggregation (DeLonay et al. 2016; Jacobson et al. 2016). This hypothesis is supported based on inferences from other sturgeon species. However, available information is not adequate to define flow pulses or hydrologic conditions that would be necessary for a reproductive response, or what functional relationships between pulse characteristics and strength of the spawning behavior response may look like.

The Missouri River Independent Science Advisory Panel (ISAP) considered the available information on the efficacy of flow pulses in relation to pallid sturgeon spawning and concluded "the spring pulse management action, as currently designed, is unnecessary to serve as a cue for spawning in pallid sturgeon" (Doyle et al. 2011). The design pulses refer to technical criteria adopted in the Missouri River annual operating plans and implemented in 2006, 2008, and 2009. The largest of the three implemented pulses was in May 2006, an increase of about 11,000 cfs above antecedent flow of 14,000 cfs. The ISAP conclusion considered that the proposed spring pulse management action had not been implemented in all years, and shovelnose and pallid sturgeon exhibited evidence of having spawned in all years studied. Spawning occurred in multiple locations, at different times, and under a wide range of geomorphic and hydraulic conditions (Doyle et al. 2011). As a result, it is anticipated that the spawning cue release under Alternative 1 would have no impact on pallid sturgeon in the lower Missouri River.

Adaptive Management

Under Alternative 1, adaptive management related to pallid sturgeon would occur through continued implementation of the SWH adaptive management strategy (USACE and USFWS 2012). This strategy focuses on evaluating the SWH creation management action. Although continued improvement of SWH habitat is anticipated to result in benefits to pallid sturgeon; this strategy has shortcomings because it does not address all of the leading potential limiting factors identified from the effects analysis. Because the actual benefits to pallid sturgeon from SWH creation are uncertain, an adaptive management strategy focused solely on this management action could also result in limited benefits compared to other adaptive management strategies.

Conclusion

Direct, adverse impacts on pallid sturgeon from ESH and SWH construction activities would be temporary, negligible, and not considered significant because population-level changes are not anticipated. Management actions under Alternative 1 are intended to benefit pallid sturgeon. Evidence is lacking to indicate the degree of relative benefits associated with each management action.

3.3.2.5 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

This section describes impacts on pallid sturgeon from management actions included in Alternative 2 that would be implemented in addition to those described in Section 3.3.2.3, “Impacts from Management Actions Common to All Alternatives.”

Mechanical ESH Construction

The nature of potential pallid sturgeon impacts from mechanical ESH construction under Alternative 2 would be the same as described for Alternative 1 (i.e., risk of entrainment, disturbance from construction activities, increased turbidity). However, the magnitude of the annual ESH construction required under Alternative 2 would be much larger than under Alternative 1 (3,546 acres annually vs. 107 acres annually). This level of ESH construction would have a higher potential to impact pallid sturgeon; however, it is anticipated that construction-related impacts on pallid sturgeon would still be negligible. Wild pallid sturgeon are not generally found in the river reaches that would include the majority of ESH construction. The timing of ESH construction (i.e., beginning in the fall once least terns and piping plovers leave and continuing until ice-out) would not occur during pallid sturgeon spawning migrations or spawning activity; further reducing the potential for impacts.

Channel Reconfiguration for Creation of Early Life Stage Habitat

Under Alternative 2, USACE would create an additional 11,265 acres of SWH between Ponca, Nebraska, and the mouth of the Missouri River to achieve a SWH target acreage of 30 acres per river mile. The impact analysis assumes that additional SWH would be created through channel widening and off-channel backwaters. Similar to Alternative 1, the habitat would be constructed to meet the updated SWH definition provided by USFWS. In general, studies to date suggest that age-0 sturgeon do not use shallow water as often as expected; however, shallow water may still be important to their survival. Construction of SWH is anticipated to result in long-term benefits to pallid sturgeon; however, these benefits of SWH are uncertain compared to other habitat or management actions.

Construction of SWH could temporarily disturb or displace pallid sturgeon in the vicinity, resulting in negligible impacts. The impacts would be site-specific and are not anticipated to affect the lower Missouri River pallid sturgeon population.

Spawning Cue Release

As described in Chapter 2.0, a bimodal spawning cue release from Gavins Point Dam would be implemented every year that specified conditions are met. The results of reservoir simulation modeling indicate that the bimodal spawning cue release would be fully implemented in 10 years over the POR. The magnitude of the spawning cue release under Alternative 2 would be larger than that for Alternative 1. As described under Alternative 1, empirical data are ambiguous regarding the behavioral responses of reproductive pallid sturgeon to flow pulses (DeLonay et al. 2009; DeLonay et al. 2016). Pallid sturgeon tracking observations near the upper Missouri and Yellowstone Rivers support the hypothesis that sufficiently large flow pulses or flow pulses relative to antecedent or adjacent flow may trigger migration and aggregation (DeLonay et al. 2016; Jacobson et al. 2016). This hypothesis is also supported based on inferences from other sturgeon species. However, available information is not adequate to define flow pulses or hydrologic conditions that are necessary for a reproductive response, or what functional relations might look like between pulse characteristics and strength of the

spawning behavior response. Although this bimodal spawning cue release would be of a larger magnitude than Alternative 1, no current scientific evidence indicates that the greater magnitude would serve as a cue for aggregation and spawning of pallid sturgeon in the lower Missouri River. Based on theoretical evidence described in Jacobson et al. (2016b), it is expected that this management action would result in some level of benefit to pallid sturgeon; however, the level of benefit, if any, to the pallid sturgeon population cannot be confirmed or quantified. A high degree of uncertainty is associated with this management action (Jacobson et al. 2016b), and it is possible that there could be no effect on pallid sturgeon.

Low Summer Flow

Under Alternative 2, low summer flows from Gavins Point Dam would occur in the 2 years following full implementation of a bimodal spawning cue release. The effects analysis identifies hypotheses that assert a more “naturalized” hydrograph, including low summer flows that may: (1) increase temperatures and residence times during the summer and fall that would increase productivity and, in turn, growth and survival of age-0 pallid sturgeon, and (2) decrease velocities that would decrease energetic demands on age-0 pallid sturgeon by decreasing foraging energy expenditures or altering the drift dynamics of food items.

Whether or not food production is limiting to age-0 pallid sturgeon is an area of considerable uncertainty. The fact that age-0 shovelnose sturgeon survive, grow, and recruit in the lower Missouri River suggests that productivity and food may not be a limiting factor (Oldenburg et al. 2010). USACE is engaged in ongoing studies investigating age-0 pallid sturgeon. Functional relations between water velocity and energetic demand have not been documented for age-0 pallid sturgeon, and actual bioenergetic demands on age-0 pallid sturgeon are likely complex and nonlinearly related to mean velocities or depth-averaged velocities (Jacobson et al. 2016).

It is highly uncertain whether or not low summer flows would directly contribute to increased survival of age-0 pallid sturgeon (Jacobson et al. 2016b). Based on theoretical evidence described in Jacobson et al. (2016b), this management action is expected to result in some level of benefit to pallid sturgeon; however, the level of benefit, if any, to the pallid sturgeon population cannot be confirmed or quantified.

Floodplain Connectivity

The amount of floodplain connectivity measured for current operations would be assumed to continue. The relation of natural flow regimes and riverine ecosystem productivity has strong theoretical roots, especially with the hypothesis that seasonal flood pulses provide episodes of connectivity, nutrient exchange with the floodplain, and flushing of organic matter to the mainstem (Junk et al. 1989; Poff et al. 1997; Sparks et al. 1998). Empirical evidence to support this management action includes substantial weight gains of pallid sturgeon after the 2011 flood (DeLonay et al. 2016) and indirect evidence of effects on pallid sturgeon, such as increased growth of some fish species after the 1993 flood on the Mississippi River (Gutreuter et al. 1999). However, specific linkages from hydrology and connectivity to age-0 pallid sturgeon diet, growth, and survival have not been documented.

As stated in Chapter 2.0, USACE determined that more than twice as much floodplain connectivity is currently provided on the System. Therefore, whatever pallid sturgeon benefits may be associated with this action are expected to continue under Alternative 2.

Adaptive Management

Under Alternative 2, adaptive management related to pallid sturgeon would occur through continued implementation of the SWH adaptive management strategy (USACE and USFWS 2012). This strategy focuses on the evaluation of the SWH creation management action. The pallid sturgeon adaptive management strategy would be expanded to address the flow-related management actions included in Alternative 2. Although this expansion is anticipated to result in benefits to pallid sturgeon from continued improvement of SWH habitat and flow management, this strategy has shortcomings because it does not address all of the leading potential limiting factors identified from the effects analysis including if there is a lack of interception of larvae to SWH. Because the actual benefits to pallid sturgeon from SWH creation and flow management are uncertain, an adaptive management strategy focused solely on these management actions would also result in limited benefits compared to other adaptive management strategies.

Conclusion

Direct, adverse impacts from ESH and SWH construction activities would be temporary, negligible, and not considered significant because population-level changes are not anticipated. Management actions under Alternative 2 are intended to benefit pallid sturgeon. Evidence is lacking to indicate the degree of relative benefits associated with each management action.

3.3.2.6 Alternative 3 – Mechanical Construction Only

This section describes the impacts on pallid sturgeon from management actions included in Alternative 3 that would be implemented in addition to those described in Section 3.3.2.3, “Impacts from Management Actions Common to All Alternatives.”

Mechanical ESH Construction

The nature of potential pallid sturgeon impacts from mechanical ESH construction under Alternative 3 would be the same as described for Alternative 1 (i.e., risk of entrainment and disturbance from construction activities). The magnitude of the annual ESH construction that would be required under Alternative 3 is larger than Alternative 1 (391 acres annually vs. 107 acres annually). This level of ESH construction is anticipated to have a low risk of adverse construction-related impacts on pallid sturgeon; therefore, impacts are considered negligible because they are not expected to have a population-level effect.

Spawning Habitat Construction

USACE would create up to three high-quality spawning sites and monitor effectiveness in terms of relative use of these sites (compared to reference bends that have not been altered) and the relative spawning success, as determined by hatch rate, catch per unit effort of free embryos, and other indicators.

The effects analysis hypotheses suggest that channel reconfiguration could increase quality and availability of spawning habitat. Improvements of spawning habitats through channel reconfiguration could achieve a combination of conditions that would be more attractive to reproducing pallid sturgeon. These improvements include creating hydraulic conditions that are favorable for egg deposition and fertilization and a hydraulic and sediment transport regime that allows for successful incubation and hatch. Spawning habitat would be developed where it could be used by migrating reproductive pallid sturgeon at or near the upstream apex of their

reproductive migrations. Based on documented upstream migrations of reproductive adults and downstream dispersal of free embryos, it is clear that spawning sites should be upstream from areas occupied by later life stages; but it is not clear if any of the documented locations would produce greater chances of hatch and survival.

Currently scientific information regarding the conditions that support functional spawning habitat is lacking. Without an improved understanding of how adults, gametes, and embryos function in the sequence from egg release through hatch, the definition of spawning habitat remains problematic. Additionally, a well-defined model for channel configuration that specifically addresses spawning habitat requirements is also lacking because of this deficit of information. Spawning sites would not be constructed until sufficient knowledge on functional spawning habitat has been gained through adaptive management to support design criteria. Creation of one to three high-quality spawning sites and the subsequent monitoring and evaluation that would occur under the AM Plan could possibly have long-term, beneficial impacts on pallid sturgeon.

Channel Reconfiguration for Creation of Early Life Stage Habitat

Under Alternative 3, USACE would create Interception and Rearing Complexes (IRC) between Ponca, Nebraska, and the mouth of the Missouri River through structure modifications, new structure placement, and channel widening. For purposes of impact analysis it is assumed construction would create up to 3,380 acres of new IRC area and create additional IRC habitat by modifying hydraulics to intercept free embryos into existing food and foraging habitats as described in Chapter 2.0. Under Alternative 3, IRCs would be constructed to include food-producing and foraging habitats as defined in the effects analysis and incorporate hydraulic conditions necessary to intercept pallid sturgeon larvae (Jacobson et al. 2016b).

Channel reconfiguration to create IRC is hypothesized to increase food-producing habitats, increase availability and quality of foraging habitat, and improve interception of free embryos based on best available science presented in the effects analysis (Jacobson et al. 2016b). This hypothesis is based on the assumption that free embryos cannot transition to exogenously feeding larvae and thrive while in the thalweg. Spawning habitat location, drift distance, interception habitat, food-producing habitat, and foraging habitat are all interrelated, and any one habitat type or combination of these factors could limit recruitment. Research suggests that specific hydraulic conditions are needed to help pallid sturgeon free embryos exit the highly engineered, highly efficient navigation channel to find food-producing and energetically supportive foraging habitats when they transition to first feeding. The idea that interception habitats may be limiting to pallid sturgeon recruitment is based on the understanding that fish must successfully transition to first feeding or they will starve and the rationale that drifting free embryos have limited opportunity to exit the thalweg of the heavily altered navigation channel once entrained.

Research also suggests that reconfiguring the channel to create more food-producing habitats would allow for greater growth and survival of exogenously feeding larvae to age-1 pallid sturgeon. This hypothesis is based on the assumption that food is a limiting resource, and that food-producing habitats can be adequately modeled with existing data and understanding. If food is limited and favorable habitat for food production is created, an increase in growth and, therefore, survival to age-1 could occur.

The effects analysis also indicates that foraging habitat needed for age-0 pallid sturgeon to feed on drifting food items may be limiting. Removing this limitation would increase growth and

survival. This conceptual idea has not been verified with field observations or data at the fine scale; however, sample collections of age-0 *Scaphirhynchus* spp. provide some support to indicate selection of a specific range of velocity (0.5–0.7 m/s) and depth (1–3 m) conditions. If foraging habitat is limiting and favorable conditions for foraging are created, this could lead to higher survival rates because fish would be in more favorable conditions to forage and grow. Uncertainties remain in understanding foraging processes, growth, and survival under field conditions and the limitations of foraging habitat related to food-producing and interception habitats. Associations between foraging habitat availability and catch per unit effort may provide supporting evidence but are unlikely to produce a causal understanding without detailed, laboratory-based studies to establish habitat preferences, bioenergetic optima, or both.

The impacts from channel widening using the IRC concept are similar to the impacts under SWH construction. Modifying structures by creating notches or lowering the structure encourages erosion of the riverbank and causes the top width of the river to increase. Construction of IRCs could temporarily disturb or displace pallid sturgeon in the vicinity, resulting in negligible, adverse impacts. The impacts would be site-specific and are not anticipated to affect the lower Missouri River pallid sturgeon population.

Construction of IRC is anticipated to result in long-term benefits to pallid sturgeon; however, the benefits of IRCs to age-0 pallid sturgeon are uncertain, compared to other habitats or management actions. Implementation of IRCs under the adaptive management framework included in the AM Plan would include monitoring and evaluating this management action to understand the extent of benefits to pallid sturgeon.

Adaptive Management including Level 1 and 2 Studies

Adaptive management for pallid sturgeon under Alternative 3 uses a framework that includes four levels of action: research (Level 1), in-river testing (Level 2), scaled implementation (Level 3), and the ultimate required scale of implementation (Level 4). The role of adaptive management in managing the pallid sturgeon is to improve decision making in light of an uncertain future system state and through improved understanding of how the system functions in response to various management actions. Decision criteria would inform whether research results warrant moving to an increased level of implementation. As an initial set of actions is implemented, the information learned through active adaptive management may result in the adjustment, continuation, or removal of the action.

Level 1 and 2 studies would be designed to gain scientific understanding that would reduce uncertainty regarding hypothesized pallid sturgeon limiting factors. As an example, Level 1 and 2 studies would be designed to reduce the uncertainty regarding spawning habitat characteristics and needs for successful production. An early emphasis would be to use information from the Yellowstone River as the best natural reference conditions to inform the design of Level 2 pilot projects on the lower river (the constructed spawning habitat referred to previously), while also continuing to examine the habitat characteristics of spawning sites on the lower river. Pilot projects on the lower river would be monitored for effectiveness based on metrics ranging from observed aggregation and spawning to the number of free embryos in the water column downstream from constructed spawning habitat. Created spawning habitat sites would be monitored and the effectiveness of the action evaluated in terms of the relative use of these sites compared to other control areas and their relative spawning success.

A one-time spawning cue test (Level 2) release may be implemented under Alternative 3, 4, and 5. 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 potential impacts from the implementation of a one-time spawning cue test release to pallid sturgeon are similar to that described for Alternative 6.

Active adaptive management for the pallid sturgeon is expected to reduce uncertainty regarding pallid sturgeon limiting factors in the most expeditious manner. Therefore, implementation of Alternative 3 under the AM Plan is anticipated to maximize long-term benefits to the pallid sturgeon population.

Conclusion

Direct, adverse impacts from ESH and IRC construction activities would be negligible and not considered significant because population-level changes would not be anticipated. Management actions under Alternative 3 are intended to benefit pallid sturgeon. Evidence is lacking to indicate the degree of relative benefits associated with each management action. Active adaptive management is expected to maximize beneficial impacts on pallid sturgeon over the long term.

3.3.2.7 Alternative 4 – Spring ESH Creating Release

This section describes the impacts on pallid sturgeon from management actions included in Alternative 4 that would be implemented in addition to those described in Section 3.3.2.3, “Impacts from Management Actions Common to All Alternatives.”

Mechanical ESH Construction

The nature of potential pallid sturgeon impacts from mechanical ESH construction under Alternative 4 would be the same as described for Alternative 1 (i.e., risk of entrainment and disturbance from construction activities). The magnitude of the annual ESH construction required under Alternative 4 would be larger than under Alternative 1 (240 acres annually vs. 107 acres annually). This level of ESH construction is anticipated to have a low risk of adverse construction-related impacts on pallid sturgeon; therefore, impacts would be negligible because they are not expected to have a population-level effect.

Spring Reservoir Release for ESH Creation

The spring reservoir release for ESH creation would differ from flow management actions that have been designed to benefit pallid sturgeon primarily by lacking a bimodal peak. The characteristic bimodal peak of spawning cue releases formulated under the MRRMP-EIS is based on mimicking of the natural hydrograph. The spring ESH-creating reservoir release would increase releases from Gavins Point for a longer duration than that of a pulse hypothesized to be beneficial to pallid sturgeon aggregation and spawning. Specific applications of spring rises to pallid sturgeon reproduction has been under investigation, but an unambiguous association between flow pulses and reproductive success of pallid sturgeon has not been established (Doyle et al. 2011; Papoulias et al. 2011; DeLonay et al. 2016). The degree of uncertainty regarding the impacts of this management action on pallid sturgeon is high. No adverse impacts on pallid sturgeon are anticipated, and little evidence supports the realization of beneficial impacts.

Spawning Habitat Construction

Spawning habitat construction would occur as described for Alternative 3. Creation of up to three high-quality spawning sites and the subsequent monitoring and evaluation that would occur under the AM Plan could possibly have long-term, beneficial impacts on pallid sturgeon. The ESH flow release may create hydraulic and sediment-transport conditions that would interact with constructed spawning habitat but positive or negative benefits are unknown.

Channel Reconfiguration for Creation of Early Life Stage Habitat

IRC construction would occur as described for Alternative 3. Under Alternative 4, USACE would create up to 3,380 acres of new IRC area between Ponca, Nebraska, and the mouth of the Missouri River. IRC would be constructed to include food-producing and foraging habitats as defined in the effects analysis and to incorporate hydraulic conditions necessary to intercept pallid sturgeon larvae (Jacobson et al. 2016b). Construction of IRCs could temporarily disturb or displace pallid sturgeon in the vicinity resulting in negligible, adverse impacts. The impacts would be site-specific and are not anticipated to affect the lower Missouri River pallid sturgeon population. Construction of IRCs is anticipated to result in long-term benefits to pallid sturgeon; however, the benefits of IRCs to age-0 pallid sturgeon are uncertain compared to other habitats or management actions. Implementation of IRCs under the adaptive management framework included in the AM Plan would include monitoring and evaluating this management action to understand the extent of benefits to pallid sturgeon. The ESH flow release may create hydraulic and sediment-transport conditions that would interact with IRCs but positive or negative benefits are unknown.

Adaptive Management including Level 1 and 2 Studies

Benefits to pallid sturgeon from active adaptive management would be the same as described for Alternative 3. Active adaptive management for the pallid sturgeon is expected to reduce uncertainty regarding pallid sturgeon limiting factors in the most expeditious manner. Therefore, implementation of Alternative 4 under the AM Plan is anticipated to maximize long-term benefits to the pallid sturgeon population.

Conclusion

Direct, adverse impacts from ESH and IRC construction activities would be negligible and not considered significant because population-level changes would not be anticipated. Management actions under Alternative 4 are intended to benefit pallid sturgeon; however, the degree to which each management action would benefit this species is unknown. Active adaptive management is expected to maximize beneficial impacts to pallid sturgeon over the long term.

3.3.2.8 Alternative 5 – Fall ESH Creating Release

This section describes the impacts on pallid sturgeon from management actions included in Alternative 5 that would be implemented in addition to those described in Section 3.3.2.3, “Impacts from Management Actions Common to All Alternatives.”

Mechanical ESH Construction

The nature of potential pallid sturgeon impacts from mechanical ESH construction under Alternative 5 would be the same as described for Alternative 1 (i.e., risk of entrainment and

disturbance from construction activities). The magnitude of the annual ESH construction required under Alternative 5 would be larger than under Alternative 1 (309 acres annually vs. 107 acres annually). This level of ESH construction is anticipated to have a low risk of adverse construction-related impacts on pallid sturgeon; therefore, impacts would be negligible because they are not expected to have a population-level effect.

Fall Reservoir Release for ESH Creation

Specific impacts on pallid sturgeon from a fall reservoir release for ESH creation are not known. Increased flows during the fall would be contrary to the pattern of the natural hydrograph; however, no evidence exists to suggest a fall reservoir release would adversely affect pallid sturgeon.

Spawning Habitat Construction

Spawning habitat construction would occur as described for Alternative 3. Creation of one to three high-quality spawning sites and the subsequent monitoring and evaluation that would occur under the AM Plan could possibly have long-term, beneficial impacts on pallid sturgeon. The ESH flow release may create hydraulic and sediment-transport conditions that would interact with constructed spawning habitat but positive or negative benefits are unknown.

Channel Reconfiguration for Creation of Early Life Stage Habitat

IRC construction would occur as described for Alternative 3. Under Alternative 5, USACE would create up to 3,380 acres of new IRC area between Ponca, Nebraska, and the mouth of the Missouri River. IRC would be constructed to include food-producing and foraging habitats as defined in the effects analysis and to incorporate hydraulic conditions necessary to intercept pallid sturgeon larvae (Jacobson et al. 2016b). Construction of IRCs could temporarily disturb or displace pallid sturgeon in the vicinity resulting in negligible, adverse impacts. The impacts would be site-specific and are not anticipated to affect the lower Missouri River pallid sturgeon population. Construction of IRC is anticipated to result in long-term benefits to pallid sturgeon; however, the benefits of IRCs to age-0 pallid sturgeon are uncertain compared to other habitats or management actions. Implementation of IRCs under the adaptive management framework included in the AM Plan would include monitoring and evaluating this management action to understand the extent of benefits to pallid sturgeon. The ESH flow release may create hydraulic and sediment-transport conditions that would interact with IRCs but positive or negative benefits are unknown.

Adaptive Management including Level 1 and 2 Studies

Benefits to pallid sturgeon from active adaptive management would be the same as described for Alternative 3. Active adaptive management for the pallid sturgeon is expected to reduce uncertainty regarding pallid sturgeon limiting factors in the most expeditious manner. Therefore, implementation of Alternative 5 under the AM Plan is anticipated to maximize long-term benefits to the pallid sturgeon population.

Conclusion

Direct, adverse impacts from ESH and IRC construction activities would be negligible and not considered significant because population-level changes are not be anticipated. Management actions under Alternative 5 are intended to benefit pallid sturgeon. Evidence is lacking to

indicate the degree of relative benefits associated with each management action. Active adaptive management is expected to maximize beneficial impacts on pallid sturgeon over the long term.

3.3.2.9 Alternative 6 – Pallid Sturgeon Spawning Cue

This section describes the impacts on pallid sturgeon from management actions included in Alternative 6 that would be implemented in addition to those described in Section 3.3.2.3, “Impacts from Management Actions Common to All Alternatives.”

Mechanical ESH Construction

The nature of potential pallid sturgeon impacts from mechanical ESH construction under Alternative 6 would be the same as described for Alternative 1 (i.e., risk of entrainment and disturbance from construction activities). The magnitude of the annual ESH construction required under Alternative 6 would be larger than under Alternative 1 (303 acres annually vs. 107 acres annually). This level of ESH construction is anticipated to have a low risk of adverse construction-related impacts on pallid sturgeon; therefore, impacts would be negligible because they would not be expected to have a population-level effect.

Spawning Cue Release

As described in Chapter 2.0, a bimodal spawning cue release from Gavins Point Dam would be implemented every year that specified conditions are met. The results of reservoir simulation modeling indicate that, in practice, the full bimodal spawning cue release would be implemented in 11 years over the POR. The magnitude of the Alternative 6 spawning cue release would be larger than that described for Alternative 1. As described under Alternative 1, empirical data are ambiguous on behavioral responses of reproductive pallid sturgeon to flow pulses (DeLonay et al. 2009; DeLonay et al. 2016). Pallid sturgeon tracking observations near the upper Missouri and Yellowstone Rivers support the hypothesis that sufficiently large flow pulses or flow pulses relative to antecedent or adjacent flow may trigger migration and aggregation (DeLonay et al. 2016; Jacobson et al. 2016). The hypothesis is supported based on inferences from other sturgeon species. However, available information is not adequate to define flow pulses or hydrologic conditions that are necessary for a reproductive response, or what functional relations might look like between pulse characteristics and strength of the spawning behavior response. The ISAP concluded that the spawning cue release as designed under Alternative 1 was unnecessary to serve as a cue for spawning in pallid sturgeon (Doyle et al. 2011). Although this bimodal spawning cue release would be larger than the one described under Alternative 1, current scientific evidence supporting the hypothesis that the greater magnitude would serve as a cue for aggregation and spawning of pallid sturgeon in the lower Missouri River is limited to extrapolation of sparse evidence from the upper Missouri River. In addition, theoretical evidence described in Jacobson et al. (2016b), suggests that this management action is expected to result in some level of benefit to pallid sturgeon; however, it is not possible to confirm or quantify the level of benefit, if any, to the pallid sturgeon population. A high degree of uncertainty is associated with this management action (Jacobson et al. 2016b), and it is possible that there could be no effect on pallid sturgeon.

Spawning Habitat Construction

Spawning habitat construction would occur as described for Alternative 3. Creation of up to three high-quality spawning sites and the subsequent monitoring and evaluation that would

occur under the AM Plan could possibly have long-term, beneficial impacts on pallid sturgeon. The spawning-flow release may create hydraulic and sediment-transport conditions that would interact with constructed spawning habitat but positive or negative benefits are unknown.

Channel Reconfiguration for Creation of Early Life Stage Habitat

IRC construction would occur as described for Alternative 3. Under Alternative 6, USACE would create up to 3,380 acres of new IRC area between Ponca, Nebraska, and the mouth of the Missouri River. IRC would be constructed to include food-producing and foraging habitats as defined in the effects analysis and to incorporate hydraulic conditions necessary to intercept pallid sturgeon larvae (Jacobson et al. 2016b). Construction of IRCs could temporarily disturb or displace pallid sturgeon in the vicinity resulting in negligible, adverse impacts. The impacts would be site-specific and are not anticipated to affect the lower Missouri River pallid sturgeon population. Construction of IRC is anticipated to result in long-term benefits to pallid sturgeon; however, the benefits of IRCs to age-0 pallid sturgeon are uncertain compared to other habitats or management actions. Implementation of IRCs under the adaptive management framework included in the AM Plan would include monitoring and evaluating this management action to understand the extent of benefits to pallid sturgeon. The spawning-cue flow release may create hydraulic and sediment-transport conditions that would interact with IRCs but positive or negative benefits are unknown.

Adaptive Management including Level 1 and 2 Studies

Benefits to pallid sturgeon from active adaptive management would be the same as described for Alternative 3. Active adaptive management for the pallid sturgeon is expected to reduce uncertainty regarding pallid sturgeon limiting factors in the most expeditious manner. Therefore, implementation of Alternative 6 under the AM Plan is anticipated to maximize long-term benefits to the pallid sturgeon population.

Conclusion

Direct, adverse impacts from ESH and IRC construction activities would be negligible and not considered significant because population-level changes are not be anticipated. Management actions under Alternative 6 are intended to benefit pallid sturgeon; however, the degree to which each management action would benefit this species is unknown.

3.3.2.10 Climate Change

Because there is uncertainty associated with the effects of management actions on pallid sturgeon populations, there is a greater uncertainty regarding how the effects of management actions would be influenced by climate change. Increased precipitation and streamflow would have an influence on how often flow management actions were implemented; however, how this may directly influence the impacts described to pallid sturgeon is unclear. Increased air temperatures could increase beneficial impacts to pallid sturgeon in some areas affected by cold water dam releases and create unanticipated adverse impacts in other areas. For example, in the lower Missouri River, river water temperature is directly influenced by air temperature. Therefore, warmer air temperatures could result in warmer river water temperatures, which may benefit primary and secondary productivity and in turn have indirect benefits to pallid sturgeon. Pallid sturgeon growth rates could also be influenced by warmer water temperatures as free embryos and larvae develop faster at higher water temperatures. In some localized areas where water temperatures are high, increased air temperature could potentially increase river water

temperatures that would stress individual pallid sturgeon (Kappenman et al. 2009; Hupfeld et al. 2015). Increased variability in wet and dry conditions could make it more challenging to maintain effective spawning and IRC habitat. Implementing any alternative within an adaptive management framework would allow for management actions to be evaluated and adjusted in order to achieve species objectives. As more information becomes available and uncertainty is reduced, adjustments to account for the observed effects of climate change could be implemented. Therefore, it is assumed that the conclusions described for each alternative would not vary substantially under the expected climate change scenario.

3.3.2.11 Cumulative Impacts

Past USACE actions included construction and operation of the System and the BSNP resulted in significant adverse impacts to pallid sturgeon as evidenced by the USFWS jeopardy opinion documented in the BiOp (USFWS 2000, 2003). As discussed in Chapter 1.0 and in the BiOp (USFWS 2000, 2003), construction of the System created physical barriers to migration of pallid sturgeon and interference with the larval drift process (Braaten et al. 2008). It is also probable that dams now prevent access to formerly used habitats—either directly or by imposing changes in water quality. Mainstem reservoirs present challenges to downstream-dispersing free embryos and may harbor lethal water-quality conditions (Braaten et al. 2008; Guy et al. 2015). The decrease in sediment load also has been associated with decreases in turbidity that might directly affect native fish fauna (Galat et al. 2005). Galat and Lipkin (2000) documented substantial alteration to the annual hydrograph downstream from the reservoirs, including reduced intra-annual flow variability with generally decreased spring pulses and increased summer low flows. Hydrologic changes are especially severe just downstream from the dams and in inter-reservoir reaches where clear, cold water is released.

Channelization and bank stabilization on the Lower River have altered habitat complexity and diminished floodplain connectivity, factors that are likely to have substantive effects on productivity and species distributions of the river (Funk and Robinson, 1974; Hallberg et al. 1979; Hesse and Sheets 1993; Galat et al. 2005; Jacobson and Galat 2006). Channelization to increase velocities for sediment transport and maintenance of the navigation channel has also increased flow of nutrients and organic matter, decreasing residence time and availability. Although effects of channelization on pallid sturgeon populations have been inferred (U.S. Fish and Wildlife Service 2003, 2014) and the theoretical basis for such stressors in aquatic ecosystems is well established (Junk et al. 1989; Sparks 1995; Tockner et al. 2000), specific linkages to pallid sturgeon populations remain undefined. Additional stressors—including increased water temperatures from outfalls and introduction of contaminants from industrial, agricultural, and municipal sources—may contribute to lack of recruitment by reduced egg quality and fitness of offspring, but the levels of contaminants associated with diminished fitness in the laboratory are substantially higher than those documented in field data (Buckler 2011). These conditions are expected to remain the same into the future.

Some of the Missouri River reservoirs are stocked artificially with various species of fishes, some non-native, to support sport fisheries (Bureau of Reclamation 2003; USACE 2003; USACE 2007; USACE 2008; USACE 2010). Past fishery stocking and management has caused a reduction in the abundance of native fishes from competition and inadequate amounts of biological resources available to support both populations; changes to the food web; and the introduction of pathogens. If the native fish community composition is altered, key prey species for pallid sturgeon may not be available for consumption, with implications for pallid sturgeon growth, condition, and reproductive success. Fishery stocking is currently ongoing and is expected to continue at similar levels in the future.

Modifications to the river channel from past and present actions causing bed degradation and aggradation has caused lower river stages and reduced groundwater elevations which may adversely impact shallow water habitats. If construction of passage at the Intake Diversion Dam is effective in improving upstream migration and increasing drift distance, and slower velocity habitat compared to existing conditions, there would be beneficial impacts to pallid sturgeon.

Actions that create, develop, and/or manage fish and wildlife habitat, including the USACE Continuing Authority Programs, USFWS National Wildlife Refuge System Lands Management, USFWS Partners for Fish and Wildlife Program, and EPA Section 319 Non-Point Source Grant Program, would have long-term beneficial impacts to pallid sturgeon. Creation of a diversity of aquatic community types that provide improved structure and composition of river habitat could benefit the pallid sturgeon.

Impacts to pallid sturgeon from invasive species (e.g., competition for resources; displacement of native species; transmission of pathogens and disease) would decrease from implementation of the USFWS Aquatic Invasive Species Program with beneficial impacts expected from monitoring habitats to determine the distribution of invasive species, rapidly responding to new invasions, and controlling established populations. The beneficial impacts are expected to continue into the future.

The actions under Alternatives 1–6 are anticipated to have beneficial impacts to pallid sturgeon. An AM Plan has been developed that will provide flexibility in dealing with remaining uncertainties such as the impacts of climate change. The net result of Alternatives 1–6 would be an incremental benefit in context of adverse past, present, and reasonably foreseeable future effects from cumulative actions and would therefore not contribute to significant adverse cumulative impacts.

3.4 Piping Plover and Least Tern

3.4.1 Affected Environment

The Northern Great Plains piping plover (*Charadrius melodus*) is a small migratory shorebird of the family Charadriidae. Adult piping plovers have an average body length of 17 cm (Palmer 1967) and generally weigh from 46 to 64 g (Haig 1992). Throughout the year, adults have a sand-colored upper body, white undersides, and orange legs. During the breeding season, adults develop orange bills and single black bands on the forehead and breast (Figure 3-23). Breeding birds lose the orange bill and bands after the breeding season but are easily distinguished from related plover species by their slightly larger size and orange legs (Haig and Oring 1988). Juvenile plumage is similar to adult nonbreeding plumage (USFWS 1988b). Juveniles acquire adult plumage the spring after they fledge (Prater et al. 1977).

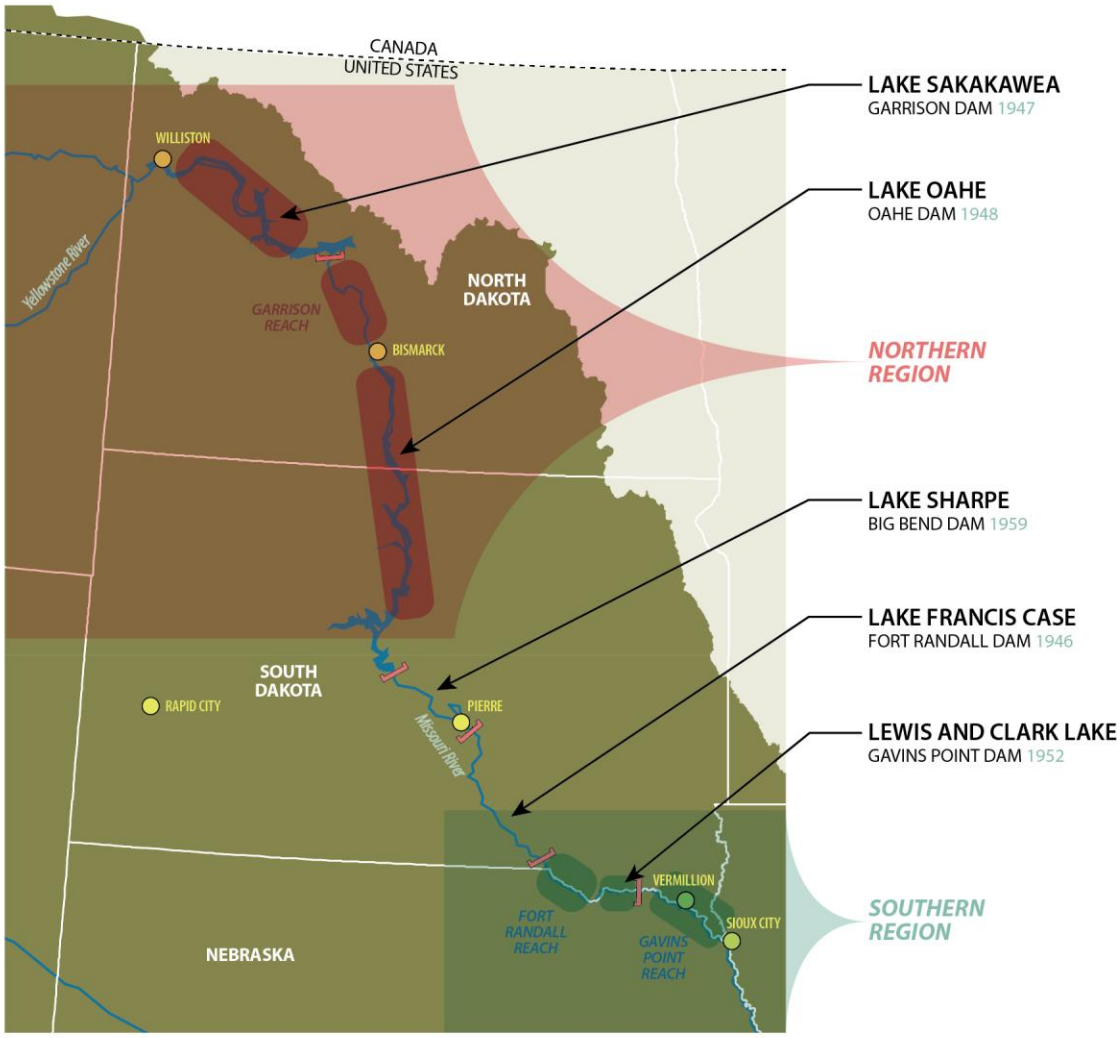
Figure 3-23. Northern Great Plains Piping Plover Adult

The interior least tern (*Sternula antillarum athalassos*) is the smallest member of the tern family in North America. These 20–22 cm birds have a black “crown” on their head, a white underside and forehead, grayish back and wings, orange legs, and a yellow bill with a black tip (Figure 3-24). Immature birds have darker plumage than adults, a dark bill, and dark eye stripes on white foreheads (USFWS 1990).

Figure 3-24. Interior Least Tern Adults

The geographic scope of this MRRMP-EIS is the Missouri River from Fort Peck Dam to the confluence with the Mississippi River. The geographic scope of USACE management for piping plovers and least terns is the mainstem Missouri River from the upper end of Lake Sakakawea near Williston, North Dakota, to Ponca, Nebraska (Figure 3-25). Plovers and terns nest in six segments within this geographic area:

- Lake Sakakawea (shoreline of the impounded river above Garrison Dam; RM 1568–1389.9)
- Garrison reach (riverine segment between Garrison Dam and Lake Oahe; RM 1389.9–1304)
- Lake Oahe (shoreline of the impounded river above Oahe Dam; RM 1304–1072.3)
- Fort Randall reach (riverine segment between Fort Randall Dam and Lewis and Clark Lake; RM 880–845)
- Lewis and Clark Lake (delta segment between Fort Randall reach and the impoundment of Lewis and Clark Lake; RM 845–811.1)
- Gavins Point reach (riverine habitat below Gavins Point Dam and above the channelized river beginning at Ponca, Nebraska; RM 811.1–754)



Source: adapted from Buenau et al. 2014

Figure 3-25. Geographic Scope of USACE Management for Terns and Plovers

Because Lake Sharpe and Lake Francis Case provide little to no nesting habitat, the resulting discontinuity in habitat availability between Lake Oahe and Fort Randall reach creates a dispersal barrier (Buenau et al. 2014). Therefore, for planning, modeling, and target-setting purposes, the mainstem habitat areas have been divided into two regions. The Northern Region includes Lake Sakakawea, Garrison reach, and Lake Oahe. The Southern Region includes Fort Randall reach, Lewis and Clark Lake, and Gavins Point reach.

The geographic scope reflects the decision-making authority of USACE. The effects of nearby subpopulations of piping plovers and least terns on Missouri River mainstem populations are not fully understood and considered a critical uncertainty.

3.4.1.1 Species Status

The Northern Great Plains piping plover population was listed as threatened on January 10, 1986, under provisions of the ESA (USFWS 1985). Critical habitat was designated on the Northern Great Plains breeding grounds on September 11, 2002 (USFWS 2015e). Critical

habitat was designated for all populations of piping plovers on the wintering grounds on July 10, 2001, and re-designated in 2008 and 2009. The breeding population of the Northern Great Plains 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 (a large plateau extending north and east of the Missouri River) in North Dakota, Montana, and extending into Canada (Figure 3-26).

In 2010, USFWS conducted a 5-year status review of the piping plover. The status review recommended retaining the piping plover's current classification (i.e., endangered in the watershed of the Great Lakes and threatened in the remainder of its range). The review indicated that the population of Northern Great Plains piping plover has increased since listing, but remains below the recovery goals set out in the 1988 recovery plan. The factors that led to the species' listing (i.e., habitat loss and degradation as a result of water management on the river systems, predation, and human disturbance), as well as other activities (e.g., growing oil and gas production) continue to threaten piping plovers on the Northern Great Plains (USFWS 2015e).

Interior least terns were listed as endangered under the ESA in 1985 (USFWS 2013). No critical habitat has been designated. 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 (Figure 3-27).

In 2013, a 5-year status review was conducted for the interior least tern. Based on the analysis of best available information, the USFWS concluded that the interior least tern is biologically recovered. Prior to initiating a delisting proposal, the USFWS indicated the following in-progress tasks must be completed.

1. Complete review of range-wide population model to determine if it further confirms assessment of status and trends.

2. Seek and obtain commitments to maintain management through conservation agreements.

3. Prepare a range-wide monitoring strategy and plan.

This management plan is intended to represent USACE's contributions to items 2 and 3 for the Missouri River.

Map adapted from the Tern and Plover Conservation Partnership http://ternandplover.unl.edu/

Figure 3-26. Map of Piping Plover Breeding Populations

Map adapted from the Tern and Plover Conservation Partnership http://ternandplover.unl.edu/

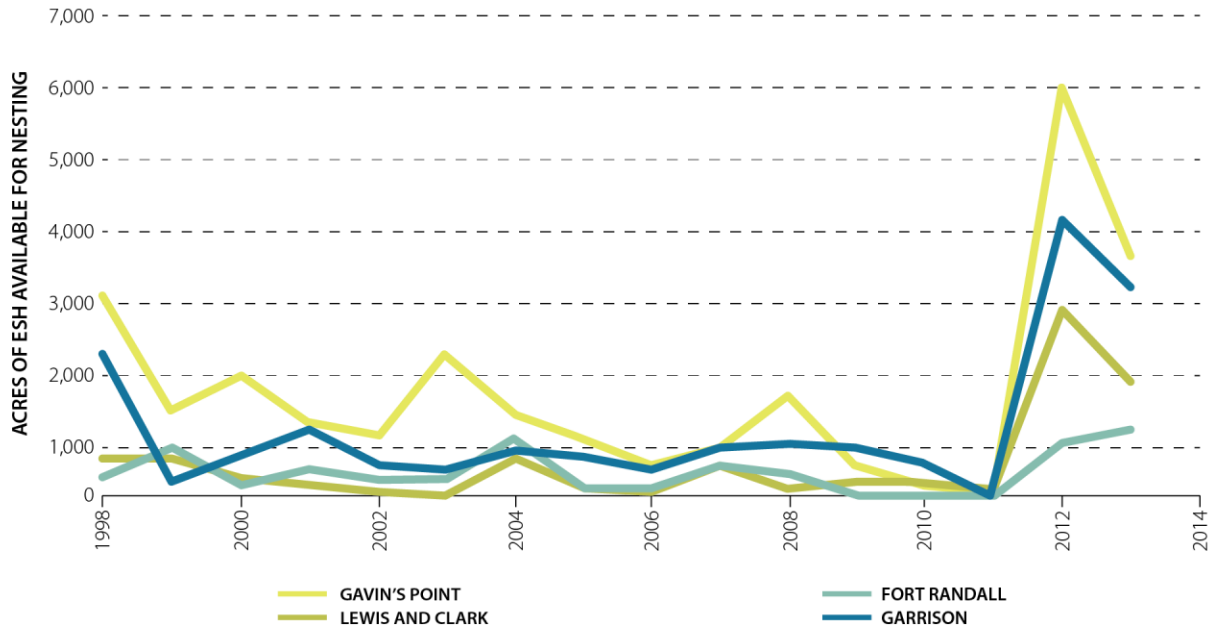
Figure 3-27. Map of Interior Least Tern Breeding Range

3.4.1.2 Life History and Ecology

Breeding Habitat

Piping plovers and least terns use sand and gravel substrates with absent or sparse vegetation for nesting and brood-rearing (Prindiville Gaines and Ryan 1998; Sherfy et al. 2012). Historically, these two species made extensive use of emergent sandbar habitat (ESH) on the Missouri and other large rivers. ESH is defined as the area of a sandbar that is wet or dry sand with less than 30 percent vegetation. Breeding plovers and their chicks forage for invertebrates on sandbar and floodplain shorelines (Catlin et al. 2011). Least terns forage for fish in shallow water, including water associated with emergent sandbars (Stucker et al. 2012). Piping plover and least tern habitat is by nature ephemeral (temporary), with fluctuating water levels periodically clearing vegetation that grows back over time during dry periods.

USACE estimates annual quantities of ESH using remote sensing classifications derived from satellite imagery. Annual estimates of ESH area have been produced using a consistent methodology since 2006. Estimates of ESH available on the river annually from 1998 to 2014 are presented in Figure 3-28.



Source: Buenau 2014
Note: Nesting Availability was calculated at maximum July flows.

Figure 3-28. Estimated Acreage of Available Emergent Sandbar Habitat (1998–2013)

Reproductive Biology

Piping plovers begin to arrive on the breeding grounds in the first half of April, with courtship and nesting beginning in mid-to-late April (Catlin and Fraser 2006; Catlin and Fraser 2007; Felio et al. 2009; Felio et al. 2010a; Felio et al. 2010b; Shaffer et al. 2013). Male plovers create a shallow depression on the ground that both adults line with small pebbles. Incubation duties last 25 to 28 days (Elliott-Smith and Haig 2004) and are shared between the male and female (Wilcox 1959, Cairns 1982). Hatching begins in late May to early June, generally peaking in

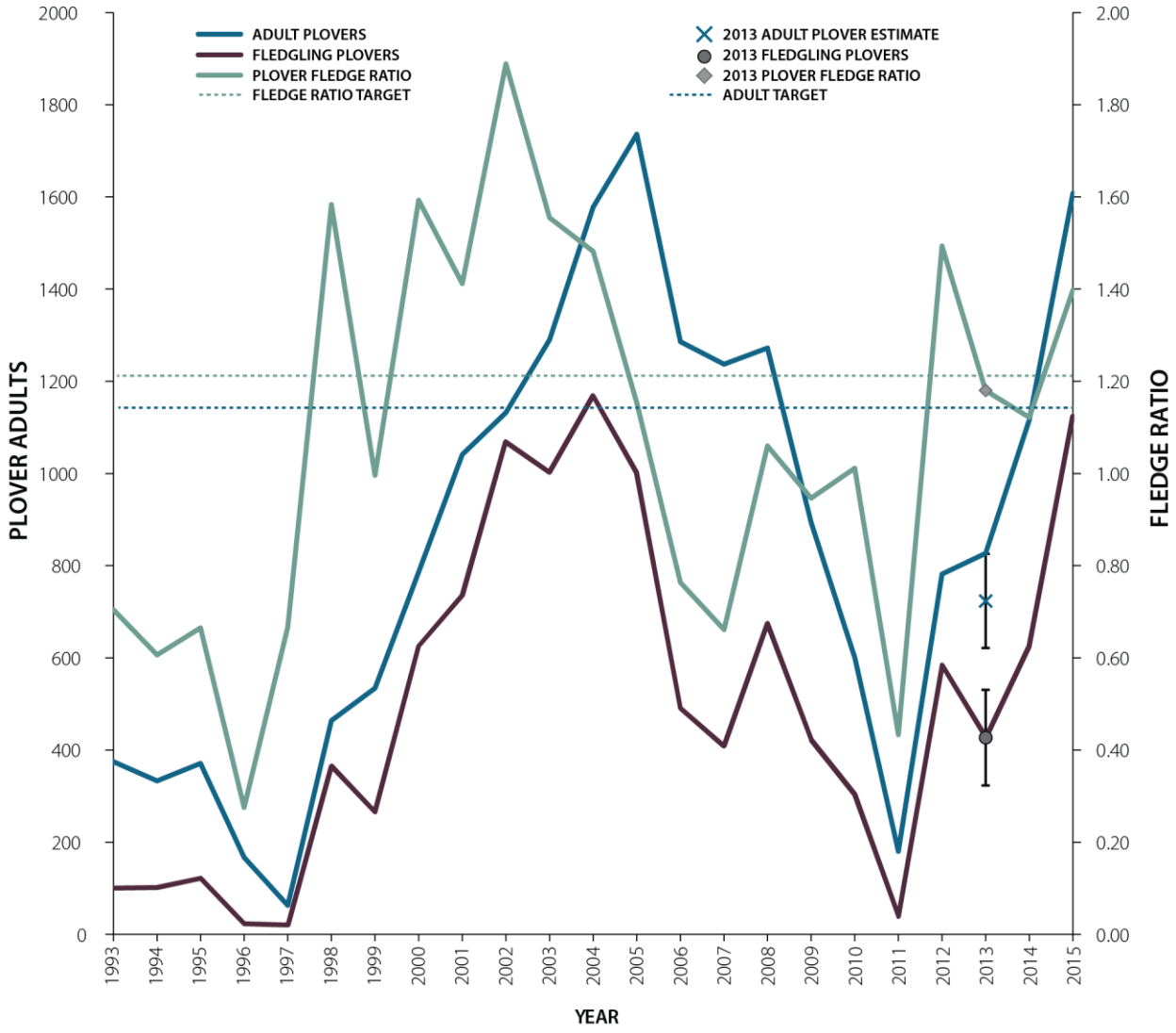
June and early July (Catllin 2009). Chicks fledge 25 to 35 days after hatching and are capable of sustained flight. Piping plovers readily renest if earlier nests fail (Whyte 1985; Haig and Oring 1988). Piping plovers begin to leave the breeding grounds as early as mid-July, with adults leaving first and juveniles last (Elliott-Smith and Haig 2004).

Interior least terns spend about 4 to 5 months at their breeding sites. They arrive at breeding areas from late April to early June (USFWS 1988a). The nest is a shallow and inconspicuous depression in an open, sandy area, gravelly patch, or exposed flat. Small stones, twigs, pieces of wood, and debris usually lie near the nest. Least terns nest in colonies, and nests can be as close as just a few meters apart or widely scattered up to hundreds of meters apart (USFWS 1988a). Egg-laying begins by late May and incubation generally lasts 20 to 25 days (USFWS 1988a). Fledging occurs after three weeks of hatch. Departure from colonies by both adults and fledglings is usually complete by early September (USFWS 1988a).

Population Distribution, Abundance, and Trends

Piping plovers only spend a portion of their lives on the Missouri River. Piping plovers that breed in the Great Plains primarily winter along the Gulf Coast, with about two-thirds of re-sightings of plovers banded in the Great Plains occurring in Texas and the remainder distributed east along the Gulf coast of Florida (Gratt-Trevor et al. 2012). The geographic scope of this MRRMP-EIS is limited to the Missouri River; however, overwinter and migration survival are important considerations to help better understand the effects of Missouri River operations on populations.

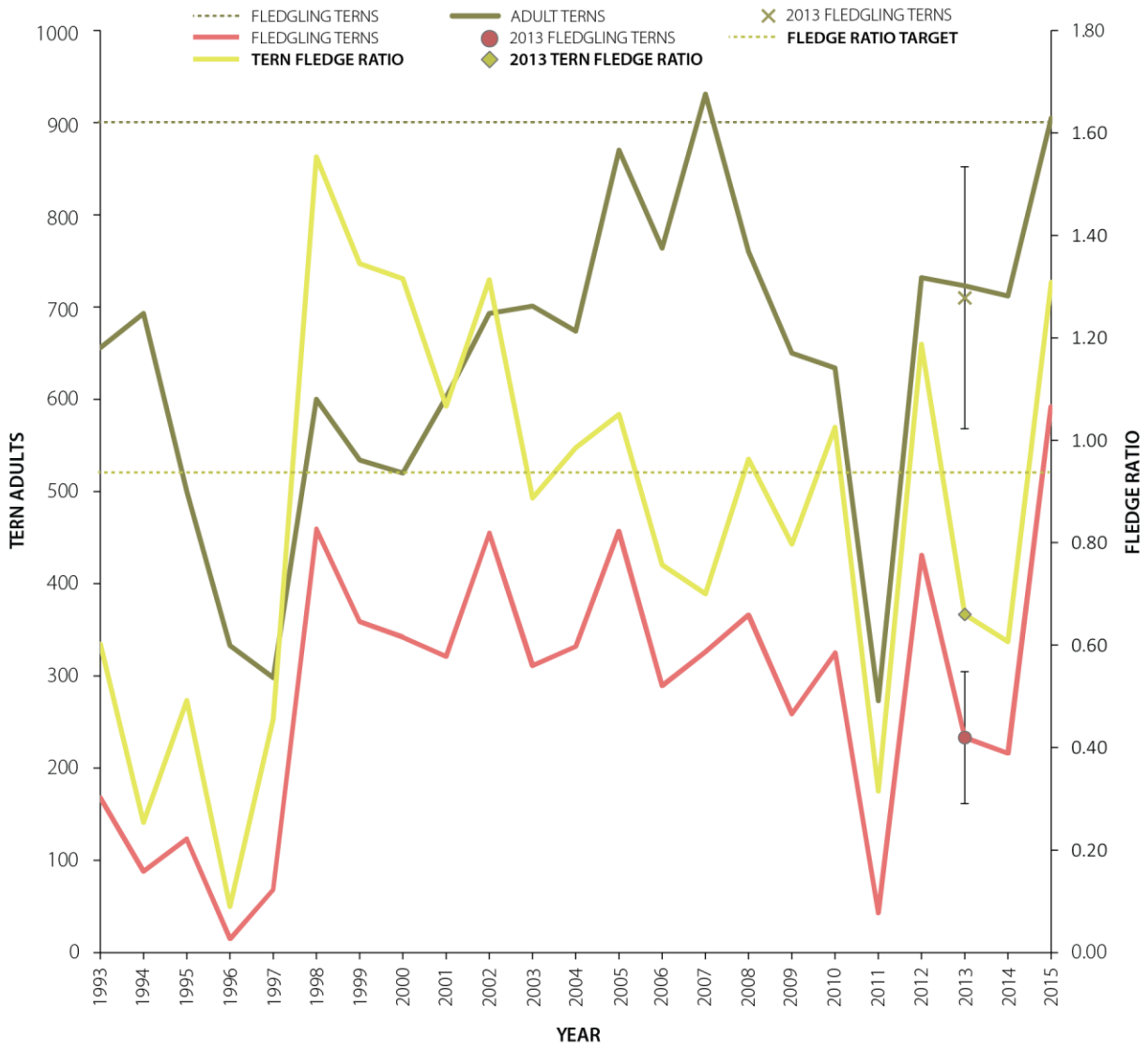
Piping plover adult numbers on the Missouri River have varied from a low of 82 in 1997 to a high of 1,764 in 2005. It should be noted that numbers are strongly driven by habitat availability in any given year; part of the Missouri River breeding population may not be counted when little to no ESH is available during high water, but many return in the following year when ESH is again available. For instance in 1998 472 adult plovers were counted on the system after the low of 82 in 1997. Population sizes increased after 1997 because of increased productivity on newly created habitat. A peak in fledge ratios preceded the peak in population sizes as a result of the lag of 1 to 2 years for birds to recruit into the breeding population. The population demonstrates an increasing trend while habitat availability decreases, which leads to a more rapid increase in population density. The largest numbers of fledglings were produced in 2004. Peak adult numbers were observed in 2005. Following those years, a general decline was observed in both productivity and population size for both species. This decline slowed somewhat because low runoff for several years led to a multi-year drawdown in reservoir levels that provided large amounts of breeding habitat. The habitat construction work done in Gavins Point and Lewis and Clark Lake beginning in 2005 also contributed to slowing the decline. Following the record high runoff of 2011, piping plover adult numbers trended sharply upward with 827 adults in 2013, 1,116 adults in 2014, and 1,612 adults in 2015 (Figure 3-29). (Note: the monitoring program was conducted differently in 2013 so values from that year are not directly comparable.)



Note: The monitoring program was conducted differently in 2013 so values from that year are not directly comparable.

Figure 3-29. Piping Plover Adult Census and Fledge Ratios for Missouri River (1993–2015)

Similar to the piping plover, least terns only spend a portion of their lives on the Missouri River, and much less is known about where least terns overwinter in Central and South America (Buenau 2014). Least tern adult numbers on the Missouri River have fluctuated over time with a high of 1,010 observed in 2007 and a low of 273 in 2011. The largest numbers of fledglings were produced in 2005. Least tern adult numbers sharply increased to 743 in 2012 following record high runoff in 2011 that inundated reservoir shoreline and sandbars and created additional habitat on the Missouri River. Tern numbers remained high in 2013, dropped slightly to 720 adults in 2014, and then increased to 917 adults in 2015. Figure 3-30 shows the least tern census results from 1993 to 2013.



Note: The monitoring program was conducted differently in 2013 so values from that year are not directly comparable.

Figure 3-30. Interior Least Tern Adult Census and Fledge Ratios for the Missouri River (1993–2015)

Threats

Reservoirs, channelization of rivers, and modification of river flows were identified in the 2010 piping plover 5-year review as major continuing threats because they reduce sandbar riverine habitat, increase flooding of remaining breeding habitat during the nesting season, and promote vegetation growth on sandbars that are rarely scoured by high flows (USFWS 2015e, 2016). Similarly, the 1988 Least Tern Recovery Plan lists actual and functional loss of riverine sandbar habitat as the central threat. However, the 5-year interior least tern review indicates that the birds are resilient to range-wide threats. Remaining threats and sources of threats to interior least terns are primarily localized (e.g., predation, vegetation of habitat, human disturbance, reservoir releases), regional (e.g., water table and flow declines), and/or stochastic (e.g., floods and droughts) and are not significant to the range-wide status of the species. The population and number of breeding colonies, and range for least terns have expanded, showing resilience

to these threats and responsiveness to continued and ongoing local management (USFWS 2013).

Flow Modification: Historically, the Missouri River provided abundant ESH that was regularly refreshed by high spring flow pulses and less frequent floods that redistributed sediment. Dam construction and operation affects the quantity and quality of ESH. The regulation of the hydrograph to reduce flood risk and provide a consistent and relatively predictable supply of water for multiple uses narrows the range of variability in flows, limiting the ability of the river to transport sediment and scour vegetation through periodic high flow and increasing the river stage in summer, inundating potential nesting habitat (Elliot and Jacobson 2006; Galat and Lipkin 2000).

Dams and Reservoirs: Dams and reservoirs trap sediment in reservoir deltas, drastically reducing the downstream supply and causing channel armoring and incision that further impede the formation of sandbars (Buenau 2014). The reservoirs themselves have inundated large areas that were formerly riverine habitat. Certain reservoirs that experience a range in water levels, primarily Lake Sakakawea and Lake Oahe, expose sand and gravel beaches when water levels decline and these beaches are available for nesting until vegetation grows. However, this habitat is only intermittently available because of fluctuating water levels and vegetation growth. In addition, routine reservoir management leads to increases in water levels during the nesting season, which inundates nests. Because this pattern is counter to natural dynamics, plovers may be attracted to sites that are not exposed long enough for eggs to hatch and thus act as ecological traps (Anteau et al. 2012a; Espie et al. 1998). Terns nest on reservoirs less frequently than plovers, although they nest on more riverine habitat in the reservoir deltas when it is available.

Predation: Predation reduces survival of eggs to chicks and survival of chicks to fledglings, with a much smaller impact on the survival of more mobile and experienced adults. Predation has been observed to be more significant when habitat is limited and nest densities are higher. Predation is also affected by nest location (e.g., whether or not nests are on floodplain-connected habitat or separated by the river channel or near gallery forest) (Buenau et al. 2014). Predation is a threat to both terns and plovers; however, plover predation rates can be reduced by caging nests whereas nest caging is not a viable management option for least terns.

Management and Protection

In 2000, USFWS issued a BiOp for listed species on the Missouri River, including piping plovers and least terns, and it issued a revised BiOp in 2003 (USFWS 2000, 2003). The primary existing management and protection for plovers and terns in the geographic scope of this plan are included as part of the RPA in the 2003 BiOp and include (1) the mechanical creation of ESH; (2) predator control; (3) vegetation management on natural and created sandbars; (4) human restriction measures; (5) flow changes to avoid take of nests below dams during the nesting season; and (6) research and monitoring. The major management actions related to terns and plovers on the Missouri River are further described in Chapter 2.0.

3.4.2 Environmental Consequences

This section considers the actions under each alternative that could have beneficial or adverse impacts on piping plovers and least terns. The management actions designed for least terns and piping plovers affect bird populations by improving the retention and formation process for habitat; increasing habitat structure, increasing availability of existing habitat, or reducing the

mortality of eggs and chicks, which contributes to population growth (Buenau in dev.). This section also analyzes the effects on piping plover and least tern from implementation of management actions aimed at pallid sturgeon.

3.4.2.1 Impacts Assessment Methodology

A habitat/population model (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. As described in Chapter 1.0, the fundamental objective for the least tern and piping plover is to avoid a finding of jeopardy to both species due to USACE actions on the Missouri River. Specific sub-objectives pertain to long-term population resilience, population growth or stability, increasing and maintaining breeding success, and maintaining geographic distribution. USFWS provided USACE with updated ESH targets rather than bird population targets for this plan. Because of the dynamic nature of both riverine and reservoir habitat availability, long-term population viability and resilience (persistence probability) is driven much more strongly by habitat than population size (Buenau 2015). A relatively large population is unlikely to persist regardless of initial size if sufficient habitat is not available in the long run. Smaller populations can persist and rebound to larger sizes if sufficient habitat is available a number of years (Buenau 2015). It is noted that this does not indicate that population size is not important for population resilience, only that standard methods using population viability models to set population size targets are not well-suited to the highly variable habitat on the Missouri River. A single population target number or meaningfully narrow range of population sizes is difficult, to derive (Buenau 2015). Past population targets were set by species recovery plans at a minimum of 1,139 piping plovers for 15 consecutive years and a minimum of 900 least terns for 10 consecutive years.

The ESH targets represent the amount of habitat necessary to produce a 95 percent probability of persistence of at least 50 individuals in each management region over 50 years. Alternatives 3–6 represent different means (e.g., mechanical construction, flow releases) of achieving the ESH targets combined with other management actions common to all alternatives such as vegetation control, predator management, and human restriction measures. The current program represented by the No Action alternative (Alternative 1) operates under the assumption that the updated ESH bird targets would not be in place and the historical average of ESH would be constructed. Under Alternative 1, an average of 107 acres of ESH per year would be constructed through mechanical construction across the northern and southern reaches when existing ESH acreage is below target or expected to be below target in the next 2 years. Under Alternative 2, 3,546 acres would need to be constructed annually. The Alternative 2 ESH targets are based on the amount of ESH that was on the System in 1998 after flooding had created approximately 11,886 acres of ESH.

Model outputs are represented as a range with a 95 percent confidence interval for the 50-year range from 2014 through 2064. The numbers used to describe environmental consequences for each alternative, in terms of the objectives, are median numbers that represent the mid-point of a range of values that the model generates, and should be used to identify trends and are not expected to predict exact values that would be observed on the ground. Available 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)

As mentioned previously, population resiliency is primarily determined by habitat availability rather than an initial population size (Buenau 2015). Therefore, the environmental consequences presented in this chapter focus on the available ESH modeled under each alternative and the corresponding extinction probability.

Modeling includes components for hydrology, riverine and reservoir shoreline habitat, and population viability. Specified rules for reservoir basin runoff operations were modified within the model to reflect changes to reservoir operations under each alternative. Historical runoff and depletions from 1930 through 2012 were used as inputs for reservoir elevations, dam releases, and river stage at selected locations. Additional details about the model are available in the AM Plan and the effects analysis reports (available online at www.moriverrecovery.org).

Alternatives were evaluated to determine potential impacts anticipated during and after implementation of each management action. Impacts on piping plovers and least terns under Alternatives 2–6 were compared to impacts under Alternative 1 (the No Action alternative), which serves as a baseline for comparison. As noted in Section 3.1.1, Impact Assessment Methodology, the No Action Alternative does not reflect actual past or future conditions but serve as a reasonable basis for comparing the impacts of the action alternatives on resources.

3.4.2.2 Geographic Scope of Impact Assessment

The geographic scope of this impact assessment is Fort Peck Dam to the confluence with the Mississippi River. Specifically, the scope is on river reaches below Garrison, Fort Randall, and Gavins Point Dams, extending downriver to the beginning of the channelized river near Ponca, Nebraska; Lake Sakakawea and Lake Oahe, which contain suitable nesting habitat on shorelines (including islands); and Lewis and Clark Lake, which contains sandbar and island habitat in its delta (Figure 3-26). The other mainstem reservoirs do not typically contain habitat to support nesting and are not a focus of management efforts.

3.4.2.3 Summary of Environmental Consequences

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). Therefore, the objectives, metrics, and targets referenced in this section refer only to the piping plover.

Table 3-9 summarizes the environmental consequences related to the piping plover over the 50-year modeled time period and the corresponding extinction probability, median growth rate, and median fledge ratio. The suite of models was run for 50 years and 5,000 iterations for each trial (Buenau 2015). Each trial assumed an ESH construction goal for each river reach to be met by annual ESH construction; the goal was adjusted until enough ESH was provided to result in meeting the population objective (i.e., less than a 5 percent (+/- <0.1 percent) risk of dropping below 50 individuals at any point in the 50 years, within either of the two regions separately). Alternatives 2, 4, 5, and 6 include flow releases that create ESH. Under these alternatives, ESH would be constructed to make up the difference between the amount of ESH created by the flow action and the remaining amount of ESH needed to reach the desired extinction probability.

Construction rates are variable for all alternatives. A summary of ESH created by each Alternative, including the range of ESH construction and percentage of years where construction is estimated to be needed, is provided in Table 2-12 in Chapter 2.0.

The one-time spawning cue test (Level 2) release that might 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.

Each action alternative under each metric considered would benefit piping plovers and least terns compared with Alternative 1. Alternative 1 would not meet the updated ESH targets or the population persistence objective. Alternative 2 would exceed the updated ESH targets and persistence objective. Alternatives 3–6 were designed to meet the updated bird objectives by meeting population persistence targets. Alternatives 3–6 would result in the same beneficial impacts on piping plovers and least terns by all meeting the ESH targets. The primary difference in Alternatives is not in their impacts on bird population metrics; it is in the contrasting impacts on human considerations and cost that are presented in other sections detailing impacts of the alternatives on the human environment.

Table 3-9. Summary of Environmental Consequences Related to Piping Plover

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Piping Plover Sub-Objective 1 (geographic distribution)	Assumed to be met if Sub-Objectives 2, 3, and 4 are met in both Regions					
Piping Plover Sub-Objective 2: North Population Extinction Probability	7.9%	2.0%	5.0%	4.9%	5.0%	4.9%
Piping Plover Sub-Objective 2: South Population Extinction Probability	46.8%	0.6%	4.9%	4.9%	5.1%	5.0%
Piping Plover Sub-Objective 3 (percent of simulated years where median $\lambda \geq 1$)	8%	98%	90%	62%	80%	54%
Piping Plover Sub-Objective 4 (percent of simulated years where median fledge ratio ≥ 1.14)	10%	98%	98%	72%	86%	56%

3.4.2.4 Impacts from Actions Common to All Plan Alternatives

Under this category the impacts of vegetation management, predator management, and human restriction measures on piping plovers and least terns are analyzed. Pallid sturgeon propagation and augmentation is another action common to all plan alternatives, but would have no impacts on piping plovers and least terns because this management action would have no impact on adult populations or nesting habitat.

Vegetation Management: Vegetation management is a means used to extend the life of constructed and flow-created sandbars for piping plover and least tern nesting. Vegetation management would be implemented on artificially constructed sandbars and naturally created sandbars based on historical use as nesting habitat. Removal and maintenance of vegetation would occur in the spring and fall outside of the piping plover and least tern nesting season. Vegetation management would be conducted as an active management technique to improve sandbars as nesting habitat. Importantly, vegetation management would reduce the number of sandbars that either would need to be created with flows or mechanically constructed. Vegetation removal would increase nesting, brood-rearing, and foraging area, which would increase survival of eggs to chicks and chicks to fledglings by reducing predation (by increasing ESH area and by removing cover for predators) and increasing foraging habitat for plovers. Therefore, the impacts of vegetation management could result in large, beneficial effects in circumstances where enough sandbars are available.

Predator Management: The objective of this management action is to improve piping plover and least tern productivity by reducing the loss of eggs and chicks to predation and reduce the number of adults that are lost or driven away from nesting areas because of disturbance by predator species. Predator management would increase survival of eggs to chicks and chicks to fledglings. Predation rates would depend on predator access and the presence of vegetation to provide cover for predators or trees present for roosting. Predators may also be attracted to higher nest densities. In a review of effects of predator removal on bird populations, predator removal resulted in an overall increase in productivity (Lavers et al. 2010). Predator management would be considered a beneficial supplement to ESH construction and management. Impacts of predator management are anticipated to result in small, beneficial impacts on piping plover and least tern in both the short and long term.

Human Restriction Measures: Disturbance to nesting birds associated with human interaction could decrease fledgling ratios. Nests may be lost to direct mechanical disturbance such as trampling or through indirect means if the parents are disturbed from the nests for long enough periods of time, especially during hot weather (Stucker and Sherfy 2007). Human restriction measures such as posting signs that restrict access to breeding areas, placing barricades to exclude human access, and outreach efforts may help to reduce human disturbance during nesting season. Human restriction measures that reduce human activity on nesting and foraging habitat could increase survival both by decreasing direct mortality and indirect effects on survival caused by stress. Decreasing human interaction with breeding piping plovers and least terns could provide small, beneficial, long-term impacts on piping plovers and least terns. Similar to predator management, human restriction measures would be a beneficial supplemental action to ESH creation and management.

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

Mechanical ESH Construction: Mechanical habitat creation would increase nesting, brood-rearing, and foraging area; which would increase survival of eggs to chicks and chicks to fledglings by reducing predation and increasing survival of chicks to fledglings by increasing food availability. Mechanical habitat creation would increase habitat area relative to the condition and availability of habitat at other breeding areas, thereby increasing the number of adults through new immigration from other areas.

The effectiveness of mechanical ESH creation has been examined through research and monitoring. Some evidence suggests that piping plovers prefer constructed sandbars to natural sandbars, and nests on constructed and maintained sandbars may have a higher daily survival rate than those on natural sandbars (Catlin et al. 2011). Differences in site selection and survival are likely strongly tied to vegetation growth on the older natural sandbars; however, the results do indicate that plovers will preferentially use and be successful on constructed habitat when natural habitat is degraded. In support of this finding, another study found that nest success for least terns was greater on newly constructed sandbars than on older natural sandbars. Nest sites on natural sandbars in this study had more vegetation than those on constructed sandbars, and proportionally more nests were found on wet substrates on natural sandbars than on constructed sandbars (Stucker et al. 2013).

Effectiveness of construction efforts on habitat availability and erosion rates of constructed habitat would depend on flows during the nesting season. High population and nest density on constructed ESH could reduce productivity through an increase in predation, and if only a few constructed sandbars support large portions of the population, they would be vulnerable to predation and localized disturbances such as storms or human activity.

Impacts related to mechanical ESH creation would vary for each alternative because the amount of habitat created positively correlates with beneficial impacts for the piping plover and least tern.

Table 3-9 shows the piping plover impacts of Alternative 1 relative to achieving the species objectives. An average of 107 acres of ESH would be constructed per year in years where construction is needed. Construction would need to occur in 83% of years according to modeling results. This amount of additional ESH on the Missouri River would result in small, beneficial impacts to piping plovers in the long term because of the increase in available nesting habitat. However, modeling indicates the probability of piping plover extinction would be 5.5 percent for the Missouri River population (i.e., northern and southern populations combined). The modeled probability of extinction would be 8 percent for the northern region and 47 percent for the southern region. Despite small, long-term benefits from mechanical ESH construction, extinction probabilities as modeled under Alternative 1 would not meet bird population objectives. The increases in extinction probability are a result of the decreasing acres of available ESH over the POR. ESH creation under this alternative would not provide the necessary amount of habitat. Reservoir conditions and resulting plover productivity would influence the population viability in the northern region. Good nesting conditions on the reservoirs could offset poor conditions on the river, and vice versa. Extinction risks in the model were lower in the northern region than in the southern region because the reservoirs in the northern region would provide some degree of habitat availability nearly every year, which is a stabilizing influence on the population.

As discussed previously, the least tern is assumed to exhibit a similar response as piping plovers to actions under Alternative 1. The model resulted in higher increases in probabilities of extinction over the entire geographic scope. Additional construction of 107 acres of ESH annually would provide small, long-term benefits to least tern.

Pallid Sturgeon Spawning Cue Release: The flow release under Alternative 1 would not be high enough or long enough to create new ESH. Water released from Gavins Point Dam for the spawning cue flows may have adverse impacts on nesting piping plovers and least terns if the birds are nesting below the dams when water is released. The timing of the second spring pulse—late May through early July—could flood nests at lower sandbar elevations. River stage at the time birds are selecting nest sites influences where birds locate their nests, thus affecting their resulting risk of inundation. Spawning cue flows could have temporary, small, adverse impacts on piping plover and least tern during spring pulses that could potentially inundate nests at lower bar elevations. USACE water management staff currently coordinate closely with USFWS when plovers and terns begin nesting below the dams. When operational flexibility exists, flow releases for authorized purposes such as flood control and navigation are released in a manner that seeks to avoid and minimize impacts on nesting birds. Avoiding and minimizing impacts on nesting birds would continue under each of the alternatives, but the timing of the pulse would likely make it impossible to avoid all impacts on nesting birds.

Mechanical Habitat Construction for Pallid Sturgeon: This management action would occur outside of the northern and southern management regions. Some least terns have been observed in the reach below Ponca (the beginning of the navigation channel) but have only recently been recorded in this reach. Nesting has occurred on sand splays resulting from dike ruptures during the 2011 flood and on sediment aggradation areas within shallow water habitat projects such as the Deer Island widening project on Lower Little Sioux Bend near Little Sioux, Iowa. The reproduction benefit to least terns is unknown from these observations, and no piping plover activity has been recorded on this reach of the Missouri River since the species was listed. This management action is anticipated to have no or negligible effect on piping plovers and least terns at the regional level.

Conclusion

No significant, adverse impacts are anticipated under Alternative 1 because this alternative is anticipated to have small, short- and long-term benefits to piping plovers and least terns. This alternative would not, however, meet the objective of providing a 95 percent chance of persistence over the 50-year modeled period and therefore would not have significant beneficial effects.

3.4.2.6 Alternative 2 – USFWS 2003 Biological Opinion Project Actions

Emergent Sandbar Habitat Construction: Under Alternative 2, an average of 3,546 acres of ESH would be constructed on an annual basis. Construction would need to occur in 100 percent of years according to modeling results. This additional ESH on the Missouri River would result in long-term, relatively large, beneficial impacts on piping plover when compared to Alternative 1 because of the increase in availability of nesting habitat. Modeling indicates the probability of piping plover extinction would be 0.3 percent by the end of the modeled period in the northern region and 0.6 percent in the southern region. Both of these values achieve the target. When compared to Alternative 1, more ESH would be created annually under Alternative 2, and the probability of extinction for both the northern and southern populations would be lower.

Pallid Sturgeon Spawning Cue Release: Modeling indicates that the spawning cue flows under Alternative 2 would be high enough to create ESH in some reaches, particularly in the Fort Randall reach. The additional habitat created by these flows would be counted toward the ESH targets under this alternative and would be considered beneficial to piping plovers and least terns in terms of habitat creation. Less habitat would need to be constructed in years where these flows create habitat. The same issues related to flooding of nesting birds associated with Alternative 1 are also a concern under this alternative.

Low Summer Flows: River stage during the nesting season helps determine how much habitat is available for nest site selection, brood rearing, and foraging. The low summer flow for pallid sturgeon would also serve as a low nesting season flow for the benefit of least terns and piping plovers. Reduced summer flows would increase the area of suitable nesting and brood-rearing habitat and foraging habitat on the river, thereby increasing fledging productivity. Generally any decrease in flow would increase habitat availability; there is not a specific discharge that would have uniform effects in all cases. The resulting increase in habitat would depend on how much sandbar structure is in the river. If few sandbars are present, less potential habitat would be available to be exposed by low flows; additionally, eroded cut banks can limit the increase in ESH resulting from lower flows. Catlin et al. (2013) observed that plover chicks took 2 to 6 days longer to fledge in high flow years (2006 and 2009) as compared to low flow years (2007 and 2008). Estimated survival also decreased in higher flow years. The mechanisms for these differences were not determined by the study, although incidental take of chicks through rising waters was not a major source of mortality. Catlin et al. (2013) hypothesize that reduced habitat availability caused by higher flows affected growth and survival through increased competition for food resources and increased predation pressure. Reduced summer flows would be most effective in conjunction with habitat-creating actions to ensure habitat is available to expose. Long-term, relatively large beneficial impacts on piping plovers and least terns are anticipated from lower summer flows that would increase the area of suitable nesting, brood rearing, and plover foraging habitat. Low summer flows could have adverse impacts on birds nesting on the reservoirs depending on inflows during low flow release periods. The net effect of this management action would ultimately depend on those relative contributions to plover population dynamics.

Conclusion

Alternative 2 modeling indicates that updated population persistence targets would be met under this alternative. In addition, beneficial actions common to all alternatives would be implemented as part of this alternative. Therefore, Alternative 2 would have significant beneficial impacts on piping plover and least tern. Because impacts of this alternative would largely be beneficial, no significant adverse impacts are anticipated.

3.4.2.7 Alternative 3 – Mechanical Construction Only

Under Alternative 3, an average of 391 acres of ESH would be constructed per year in years where construction is needed. Construction would need to occur in 75% of years to meet population persistence targets according to modeling results. This creation of additional ESH on the Missouri River would result in long-term, large, beneficial impacts on piping plover relative to Alternative 1 because of the increase in availability of nesting habitat. Modeling indicates the probability of piping plover extinction would be approximately 5.0 percent in the northern region, 4.9 percent in the southern region, and 1.4 percent across both regions by the end of the modeled period. The probability of extinction of the two regions combined would generally be lower because the likelihood of the combined population dropping below the extinction threshold

(i.e., 5 percent) would be lower than an individual region's population dropping below the threshold. When compared to Alternative 1, more ESH is created annually under Alternative 3, and the probability of extinction for both the north and south populations are lower.

Conclusion

Alternative 3 modeling indicates that updated population persistence targets would be met under this alternative. Additionally, other beneficial actions common to all alternatives would be implemented. Therefore, Alternative 3 would have significant, beneficial impacts on piping plover and least tern. Because impacts of this alternative are largely beneficial, no significant adverse impacts are anticipated.

3.4.2.8 Alternative 4 – Spring Emergent Sandbar Habitat Creating Release

Under Alternative 4, an average of 240 acres of ESH would be constructed per year in years where construction is needed in addition to the Spring ESH creating release. Construction would need to occur in 49% of years to meet population persistence targets according to modeling results. The creation of additional ESH on the Missouri River would result in long-term, relatively large beneficial impacts on piping plover because of the increase in availability of nesting habitat. According to the model, the probability of piping plover extinction would be approximately 4.9 percent in the northern and southern regions and 1.4 percent across both reaches by the end of the modeled period throughout the entirety of the geographic scope. The probability of extinction of the two regions combined is generally lower because the likelihood of the combined population dropping below the extinction threshold (i.e., 5 percent) is lower than an individual region's population dropping below the threshold. When compared to Alternative 1, more ESH would be created annually under Alternative 4, and the probability of extinction for both the northern and southern populations would be much lower. It is anticipated that Alternative 4 would result in long-term, relatively large benefits to the piping plover.

Spring Emergent Sandbar Habitat-Creating Reservoir Release: Habitat-creating flows of sufficient magnitude (i.e., high relative to the elevation of existing sandbars) and duration (i.e., sufficient enough to build sandbars) have the potential to mobilize and deposit sediment at high enough elevations to create new sandbars when water levels recede, thereby increasing the area of nesting, brood rearing habitat, and foraging habitat and increasing fledgling productivity. The ESH model predicts the acres of ESH created by high flows. Water released from dams during spring ESH creation has the potential to add additional ESH in both regions. Tern and plover population dynamics following high flows in 1997 and 2011 indicate that sufficiently high flows produce population increases in subsequent years. The spring emergent sandbar habitat-creating reservoir release modeled as part of Alternative 4 would have long-term, relatively large beneficial impacts from the creation of new sandbars that could occur following flows.

Conclusion

Alternative 4 modeling indicates that updated population persistence targets would be met under this alternative. Additionally beneficial actions common to all alternatives would be implemented as part of Alternative 4. Therefore, Alternative 4 would have significant, beneficial impacts on piping plover and least tern. Because impacts of this alternative would be largely beneficial, no significant, adverse impacts are anticipated.

3.4.2.9 Alternative 5 – Fall Emergent Sandbar Habitat Creating Release

Under Alternative 5, an average of 309 acres of ESH would be constructed per year in years where construction is needed in addition to a fall ESH creating release. Construction would need to occur in 63 percent of years to meet population persistence targets according to modeling results. The construction of additional ESH on the Missouri River would result in long-term, relatively large, beneficial impacts on piping plover because of the increase in availability of nesting habitat. Modeling indicates the probability of piping plover extinction would be approximately 1.5 percent by the end of the modeled period throughout the entirety of the geographic scope. The model predicts that the probability of extinction for both the northern and southern regions would be similar (is approximately 5 percent). The probability of extinction of the two regions combined is generally lower because the likelihood of the combined population dropping below the extinction threshold (i.e., 5 percent) is lower than an individual region's population dropping below the threshold. When compared to Alternative 1, more ESH would be created annually under Alternative 5, and the probability of extinction for both the northern and southern populations would be much lower. It is anticipated that Alternative 5 would result in long-term, relatively large benefits to the piping plover.

Fall Emergent Sandbar Habitat-Creating Reservoir Release: Fall flow releases would be designed to increase dam releases to transport and deposit sediment, create new sandbars, and increase the area and complexity of existing sandbars. Increases in sandbar area would reduce nest density, improve foraging areas, reduce predation, and consequently improve nesting success, chick survival, and overall population growth, while terns and plovers are not present. Tern and plover population dynamics following high flows in 1997 and 2011 indicate that sufficiently high flows produce population increases in subsequent years. Water released from dams during fall ESH creation has the potential to add additional ESH in both regions. The fall emergent sandbar habitat-creating reservoir release modeled under Alternative 5 could have long-term, relatively large beneficial impacts from the creation of new sandbars that could occur following flows.

Conclusion

Alternative 5 modeling indicates that updated population persistence targets would be met under this alternative. Additionally, beneficial actions common to all would be implemented as part of this alternative. Therefore, Alternative 5 would have significant, beneficial impacts on piping plover and least tern. Because impacts of this alternative would be largely beneficial, no significant adverse impacts are anticipated.

3.4.2.10 Alternative 6 – Pallid Sturgeon Spawning Cue

Under Alternative 6, an average of 303 acres of ESH would be constructed per year in years where construction is needed. Construction would need to occur in 71 percent of years to meet population persistence targets according to modeling results. The construction of additional ESH on the Missouri River would result in long-term, relatively large, beneficial impacts to piping plover because of the increase in availability of nesting habitat. According to the model, the probability of piping plover extinction would be approximately 1.5 percent by the end of the modeled period throughout the entirety of the geographic scope. The model predicts that the probability of extinction in both the northern and southern region would be similar (approximately 5 percent). The probability of extinction of the two regions combined is generally lower because the likelihood of the combined population dropping below the extinction threshold (i.e., 5 percent) is lower than an individual region's population dropping below the threshold.

When compared to Alternative 1, more ESH would be created annually under Alternative 6, and the probability of extinction for both the northern and southern populations would be much lower. It is anticipated that Alternative 6 would result in long-term, relatively large benefits to the piping plover.

Spawning Cue Release. Impacts on piping plover and least tern from the spawning cue flow under Alternative 6 would be similar to those as described under Alternative 2. Spawning cue flows could have temporary, relatively small, adverse impacts on piping plover and least tern during spring pulses that could potentially inundate nests at lower bar elevations and long-term, relatively small, beneficial impacts from the creation of new sandbars that could occur following flows.

Conclusion

Alternative 6 modeling indicates that updated population persistence targets would be met under this alternative. Additionally, beneficial actions common to all alternatives would be implemented under Alternative 6. Therefore, Alternative 6 would have significant, beneficial impacts on piping plover and least tern. Because impacts of this alternative would be largely beneficial, no significant adverse impacts are anticipated.

3.4.2.11 Climate Change

Alternatives that rely on releases from the dams to create ESH could be affected. Spring releases may be able to run more frequently due to System storage rising earlier in the year, however the number of complete Spring releases could decrease because flood targets may be exceeded more frequently. Fall releases for ESH creation may run less frequently if storage level is lowered due to less snow accumulation and earlier snowmelt. The potential for an increase in natural flood events could create nesting habitat and an increase in droughts could expose more habitat. These conditions could potentially be beneficial because of the increased nesting habitat from flood-deposited sandbars and increase in exposed sandbars under drought conditions. The amounts and frequency of habitat creation and methods used to supplement habitat creation would need to remain flexible to respond to ongoing uncertainty associated with climate change. A detailed AM Plan has been developed to deal with the types of uncertainty inherent in managing for piping plovers and least terns under variable future conditions.

3.4.2.12 Cumulative Impacts

The Missouri River mainstem reservoir system construction affected the availability of nesting habitat for the piping plover and least tern. The regulation of the hydrograph narrowed the range of variability in flows, limiting the ability of the river to transport sediment and scour vegetation through periodic high flows as well as increasing the river stage in summer, inundating potential nesting habitat (Elliot and Jacobson 2006; Galat and Lipkin 2000). Missouri River mainstem dam releases from May to August strongly affect the reservoir levels and river stages during the time of year when terns and plovers are nesting. Altered flows can destroy nests, altering the nest success of piping plover and least tern, and affect piping plover foraging habitat and food availability. Altered water temperatures can lead to changes in macroinvertebrate prey availability on sandbars that piping plovers use for foraging habitat (LeFer 2006; Lee 2007).

The reservoirs themselves have inundated a large area of formerly riverine habitat. The reservoirs that experience a range in water level fluctuation, primarily Lake Sakakawea and Lake Oahe, have sand and gravel beaches exposed when water levels decline that become

available for nesting. However, this habitat is only intermittently available due to fluctuating water level and vegetation growth. As this pattern is counter to natural lake dynamics, plovers may be attracted to sites that are not exposed long enough for eggs to hatch and thus act as ecological traps (Anteau et al. 2012; Espie et al. 1998). Terns nest on reservoirs less frequently than plovers, although they nest on riverine-like habitat in the reservoir deltas when it is available. The relatively large stretch of impounded river between Oahe Dam and Fort Randall Dam (Lake Sharpe and Lake Francis Case) that do not provide nesting habitat act as a dispersal barrier, especially to plovers, effectively separating the Missouri breeding populations of both species into a northern and southern subpopulation (Lott et al. 2013; Mcgowan et al. 2014).

Changes in channel form from Missouri River mainstem reservoir system construction and the BSNP construction have changed the likelihood and type of sediment transport at particular locations and affected the ability of sandbars to form in appropriate locations. The dams and reservoirs also trap sediment in reservoir deltas, drastically reducing the downstream supply and causing channel armoring and bed degradation that further impede the formation of sandbars (Buenau et al. 2014).

Channelization and bank stabilization on the lower Missouri River have altered habitat complexity and diminished flood plain connectivity, factors that are likely to have substantive effects on productivity and species distributions of the river (Funk and Robinson 1974; Hallberg et al. 1979; Hesse and Sheets 1993; Galat et al. 2005; Jacobson and Galat 2006). These actions have affected the available habitat (i.e., suitable nesting and brooding habitat; foraging habitat) and ecological responses (i.e., nest elevation; nest density; predation; agonistic behavior; immigration and emigration) of terns and plovers on the Missouri River mainstem. These conditions are expected to remain the same into the future.

As the floodplain becomes more developed, human disturbance will be a continuing and likely increasing threat to breeding piping plovers (USFWS 2009c). Human disturbance was identified as a continuing threat in the piping plover 5-year review conducted by the USFWS in 2009. The review states that human disturbance is a particular issue in popular river or reservoir reaches where up to about 70% of the Northern Great Plains plovers in the United States nest depending on the year. The USACE seeks to minimize the impacts from human disturbance on the Missouri River by erecting signs and fencing in order to inform the public to keep away from nesting plovers.

The Baaken formation in North Dakota, Montana, and Saskatchewan underlies major piping plover nesting areas on the alkali lakes and Missouri River system (USGS 2008). In North Dakota and Montana, oil production near plover nesting habitat has increased substantially, and many oil wells are near plover nesting areas (USFWS 2009c). The oil and gas activity may be placed near to piping plover nesting beaches, impacting reproduction directly. Oil spills may also impact nesting piping plover habitat. Since the piping plovers generally nest at the bottom of watersheds, any spill could likely migrate to the nesting areas (USFWS 2009c). The impacts from oil development are unknown but potentially substantial (USFWS 2009c). Construction related to staging for seismic surveys, new road construction, powerlines, oil wells, and other associated infrastructure have the potential to impact nesting habitat. Once a well has been established the reserve pits are a concern as other migratory birds have been documented to have been found in oil pits.

The MNRR enabling legislation, Wild and Scenic Rivers Act, the NPS Organic Act, and General Management Plans charge NPS to manage all Missouri River reaches included within the

designation in order to preserve, protect, and enhance river values for the benefit and enjoyment of present and future generations (NPS, in development). Although MNRR is located within a disturbed riverine system, the relatively free-flowing nature, including the lack of extensive river bank stabilization and varied flows from Gavins Point and Fort Randall Dams, allows for the formation and maintenance of floodplain-connected and inter-channel sandbars that serve as nesting habitat for piping plovers and least terns. MNRR currently coordinates with USACE, USFWS, and other partners to insure the federally listed species have adequate habitat in compliance with the Endangered Species Act while simultaneously ensuring that MNRR's resource values, including its free-flowing condition, water quality, "Outstandingly Remarkable Values" (scenic, cultural, fish and wildlife, ecological, geology, recreation), and other NPS or Wild and Scenic River mandates are not compromised.

Cumulative actions have affected piping plovers and least terns on the Missouri River by reducing the availability of suitable nesting habitat. The actions under Alternatives 1–6 are anticipated to have beneficial impacts by providing additional nesting habitat, predator management, and human restriction measures. An AM Plan has been developed that will provide flexibility in dealing with remaining uncertainties such as the impacts of climate change. The net result of Alternatives 1−6 would be an incremental benefit in context of adverse past, present, and reasonably foreseeable effects from cumulative actions and would therefore not contribute to significant adverse cumulative impacts.

3.5 Fish and Wildlife Habitat

3.5.1 Affected Environment

The Missouri River and its floodplain 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 in its waters and on its floodplain and 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 (i.e., main channel, secondary channels and chutes, backwaters, and floodplain lakes/oxbows) of varying depths. Terrestrial habitats generally include wetlands, forests, woodlands, grasslands, and shrublands.

Over the past 150 years humans have altered the Missouri River from its natural form through channelization, impoundment from dams and levees, bank stabilization, dredging, disconnection of the river and floodplain, and modified geomorphology and hydrology, creating numerous changes to river and floodplain fish and wildlife habitat. The amount of precipitation from rainfall and snowmelt and the presence and operation of upstream dams influence flows. The presence of the levees prevents elevated flows from spilling across the floodplain and inundating areas that were once connected to the river and were important in the formation and maintenance of aquatic and floodplain habitats. Channelization structures also direct flows in a manner that creates a self-scouring channel. During this timeframe large portions of fish and wildlife habitat have been converted to agriculture, urban areas, and open water reservoirs.

3.5.1.1 Fish and Wildlife Habitat

A modeling approach was used to describe and evaluate fish and wildlife habitat. Habitat classes were selected based on the ecological systems and alliances of the U.S. National Vegetation Classification (NatureServe 2009) and were further defined by the frequency or duration of inundation over the year or during the growing season. Each of the individual habitat classes are comprised of representative vegetation communities and plant species that were assumed to occur under the same inundation regime. Broad habitat classes, defined under a specific inundation regime, were used as a necessary measure to simplify the relationships used for modeling purposes. The terrestrial and aquatic habitats modeled in and adjacent to the river channel include open water, emergent wetland, scrub shrub wetland, riparian woodland/forested wetland, forest, and upland grassland. More information regarding the representative vegetation communities and the associated inundation regimes that make up each of the habitat classes and the species within those communities can be found in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org). These habitat classes vary in species composition across the mainstem due to the expansive north south extent of the Missouri River and the complex physical features that range throughout the basin.

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 (Table 3-10).

Table 3-10. Missouri River Study Reaches

	River Reach
Upstream of Gavins Point Dam	Fort Peck Dam to Garrison Dam
	Garrison Dam to Oahe Lake
	Fort Randall Dam to Gavins Point Dam
Downstream of Gavins Point Dam	Gavins Point Dam to Rulo, Nebraska
	Rulo, Nebraska to Kansas River
	Kansas River to Grand River
	Grand River to Osage River
	Osage River to Mouth of the Missouri River

River-floodplain connectivity and the related flooding and inundation of fish and wildlife habitats can influence the amount, quality, distribution, and variety of habitats available to fish and wildlife. Flows and channel geometry, or other physical components of the river can positively or negatively impact the availability of habitat. Low flows can increase habitat availability for terrestrial and aquatic species that use either exposed shoreline habitats or the shallows. High flows can create new habitat or condition other habitat for species to use the next year. Diverse river channel morphology and channel dimensions provide a variety of conditions in the river, such as varying depths and water velocities that support life processes for many species.

Open water habitats (i.e., main channel, secondary channels, chutes, open water sloughs, backwaters, oxbows, and pools) provide a diverse range of flows and depths that provide habitat for various assemblages including large river fish (e.g., sicklefin chub [*Macrhybopsis meeki*]) and macroinvertebrates (e.g., mayfly [*Pseudocloeon* spp.]), spawning and juvenile fish, shorebirds, turtles (e.g., common snapping turtle [*Chelydra serpentina*]), migratory birds, and furbearers (e.g., muskrat [*Ondatra zibethicus*]). Habitat needs encompassed under the open water habitat class include fish spawning habitat; feeding and breeding habitat for migratory birds and furbearers; breeding, nesting, and foraging habitat for shorebirds; and habitat for macroinvertebrates consumed by aquatic and terrestrial species. A variety of species, including avian species, forage in open water habitat along the river.

Emergent wetland habitat provides foraging, breeding, rearing, nesting, and shelter habitat for assemblages of species including intermittent/permanent pool species (e.g., tiger salamander [*Ambystoma tigrinum*]), ephemeral pool species (e.g., American toad [*Bufo americanus*]), fish and amphibians that require emergent wetlands during spawning/nursery and breeding periods, and waterfowl that forage in emergent wetlands. Fringe wetlands and vegetated mudflats provide a link between the channel and backwaters and provide a refuge for young of the year fish and juvenile turtles as currents are slow and predators are less abundant.

The riparian woodland/forested wetland, scrub-shrub wetland, and forest habitats provide habitat directly and indirectly for assemblages of species that require woody debris either on the floodplain or woody debris that is washed into the river (e.g., flathead catfish [*Pylodictis olivaris*], long-toed salamander [*Ambystoma macrodactylum*]), early successional woody habitat (e.g., prairie warbler [*Dendroica discolor*]), cavities for nesting (e.g., barred owl [*Strix varia*]), standing snags (e.g., herons and egrets [*Ardea* and *Egretta* spp.]), and berry, seed, fruit, and mast food sources (e.g., bur oak (*Quercus macrocarpa*]). The presence of woody debris in the river is an important habitat (e.g., cover, nursery habitat, basking areas) for the life history of many species

and is used by many species on the floodplain for various life history requirements (e.g., shelter, laying eggs). The variable canopy structure and diversity of understory within these habitat classes provide a variety of different habitats and food sources specific to individuals and assemblages of species. These habitat classes provide nesting, denning, roosting, basking, breeding, shelter, and foraging habitat for many wildlife species. Upland grassland habitat provides for the needs of assemblages including grazing and browsing species (e.g., deer [*Odocoileus* spp.]), grassland birds (e.g., common yellowthroat [*Geothlypis trichas*]), rodents, snakes, and insects (e.g., ottoe skipper [*Hesperia ottoe*]) that require short, mid, and tall grass prairie habitats for breeding, nesting, and foraging.

3.5.1.2 Fish and Wildlife Habitat Relationships

Fish and wildlife habitats on the Missouri River are dynamic and transition to and from different habitat classes over time depending on level, duration, and timing of inundation. The species composition of these aquatic and terrestrial habitats varies depending on a specific inundation regime and length of the growing season. These factors, in addition to other factors such as soils, natural disturbances, topography, and management practices, drive the transitional states of each habitat class and can be used to define what habitat types occur and to what extent they exist across the Missouri River basin.

While a range of inundation periods could occur within each of the representative vegetation communities within individual habitat classes, a specific number of days of inundation were assumed for modeling purposes. The timing and duration of different flows occurring throughout the river relative to the timing and duration of the growing season can influence the assemblage of species and habitat classes that occur along the Missouri River. The beginning and end dates for the growing season in each of the eight study reaches and the approximate percent of time each habitat class must be inundated for it to persist are described in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

The different thresholds that define the inundation requirements for each of the habitat classes are dynamic and in a constant state of transition. For example, over time, if the open water habitat class containing channels, chutes, oxbows, and pools were to be inundated less than the entire year for multiple years in a row, other species may be allowed to colonize and a transition to a drier habitat class, such as emergent wetland or scrub shrub wetland may occur. Habitat classes that are typically inundated more frequently and for a longer period of time, such as emergent wetland, may transition to a drier habitat class like scrub shrub wetland or forest if a prolonged drought were to occur and the habitat class was inundated less frequently and for shorter periods of time.

3.5.1.3 Fish and Wildlife Habitat Classes

The ecosystem functions model (HEC-EFM) and HEC-RAS models were used to estimate the total number of acres of habitat under current conditions for each of the habitat classes within all study reaches. Total acres of aquatic and terrestrial habitat were tabulated for each of the study reaches and then for the habitat classes within each reach. The acres represent the median amount of habitat acres for each of the habitat classes from the POR. Each reach is characterized by the six habitat classes and the amount of acres within the reach that meet each habitat class threshold.

Open water represents a dominant habitat class across all of the study reaches. In the northern reaches of Fort Peck to Garrison, Garrison to Oahe, and Fort Randall to Gavins Point scrub shrub wetland is the most common habitat class other than open water. In the southern reaches of Rulo to Kansas, Kansas to Grand, Grand to Osage, and Osage to the mouth of the Missouri River upland grassland is the most prevalent habitat class after open water.

3.5.1.4 Wetland Habitat Classes

The HEC-EFM and HEC-RAS models were used to estimate the total number of acres of wetland habitat under current conditions for each of the wetland habitat classes (emergent wetland, scrub shrub wetland, and riparian woodland/forested wetland) in all study reaches. Total acres of wetland habitat classes were tabulated for each of the study reaches and then for the wetland habitat classes within each reach. The acres represent the median amount of habitat acres for each of the wetland habitat classes from the POR. Each reach is characterized by the three wetland habitat classes and the amount of acres within the reach that meet each wetland habitat class thresholds.

Emergent wetland is the most pervasive wetland habitat class in the Garrison to Oahe, Gavins Point to Rulo, Rulo to Kansas, Kansas to Grand, and Grand to Osage reaches. In all other reaches, scrub shrub wetland was the dominant wetland habitat class. Although riparian woodland/forested wetland is not the most common habitat class in any of the study reaches, it is the second most common habitat class in the Fort Peck to Garrison reach.

3.5.1.5 Depth Classes

The depth class metric subdivides the open water habitat class, included under the acres of fish and wildlife metric, into depth classes and further describes habitat diversity within the open water habitat class. Total acres of depth classes within each period were tabulated for each of the study reaches. The acres represent the median amount of depth class acres for each of the periods from the POR. Each reach is characterized by the five periods and the six depth classes and the amount of acres within the reach.

The HEC-EFM and HEC-RAS models and the Cross Section Viewer software were used to estimate the total acres of depth classes under current conditions for each depth class (0–3 feet, 3–6 feet, 6–9 feet, 9–12 feet, 12–18 feet, and greater than 18 feet), and for each biologically relevant period (Overwintering late: January 1 – February 28/29, Early spawning: March 1 – May 14, Late spawning: May 15 – June 30, Summer rearing and growth: July 1 – September 30, Overwintering early: October 1 – December 31), in all of the four upper study reaches. Depth classes in the four lower reaches are reported together.

The 12–18 feet depth class has the greatest amount of acres for all periods in the Fort Peck to Garrison, Garrison to Oahe, and Fort Randall to Gavins Point reaches. The greater than 18 feet depth class has the greatest amount of acres for all periods, except the overwintering late period, in the Gavins Point to Rulo and the Rulo to the mouth of the Missouri River reaches. The 12–18 feet depth class has the greatest amount of acres for the overwintering late period in the Gavins Point to Rulo and Rulo to the mouth of the Missouri River reaches. The 12–18 feet depth class in the late spawning period has the greatest amount of acres in the Fort Peck to Garrison and Garrison to Oahe reaches. The 12–18 feet depth class in the summer rearing and growth period has the greatest amount of acres in the Fort Randall to Gavins Point reach. The greater than 18 feet depth class in the summer rearing and growth period has the greatest amount of acres in the Gavins Point to Rulo reach. The greater than 18 feet depth class in the late

spawning period has the greatest amount of acres in the Rulo to the mouth of the Missouri River reach.

3.5.1.6 Flow Occurrences Below 9,000 cfs for the Fort Randall to Gavins Point Reach

The number of occurrences of flows of 9,000 cfs or less within a 24-hour period in the Fort Randall reach is considered indicative of impacts to fish and wildlife within that reach. These low flows dewater riverine backwaters and have detrimental effects on aquatic insect production which is vital to support higher trophic level organisms such as fish and birds. Hourly flow data for each day within the POR was generated by the USACE Hydropower Analysis Center using the Missouri River Hydropower Benefits Calculator (HBC) and used to calculate this frequency of occurrence. An increase in the number of flow occurrences below 9,000 cfs would represent adverse impacts on fish and wildlife habitat classes and associated assemblages and taxa in the Fort Randall reach.

3.5.1.7 Invasive Species

In the Missouri River basin, a number of invasive plant and animal species have encroached upon the native habitat of the Missouri River and its floodplain.

Major invasive aquatic plants in the Missouri River mainstem include curlyleaf pondweed (*Potamogeton crispus*) and Eurasian watermilfoil (*Myriophyllum spicatum*). Major invasive terrestrial plants in the Missouri River floodplain include saltcedar (*Tamarix* spp.), Russian olive (*Elaeagnus angustifolia*), Canada thistle (*Cirsium arvense*), honeysuckle (*Caprifoliaceae* spp.), Johnsongrass (*Sorghum halepense*), garlic mustard (*Alliaria petiolata*), and leafy spurge (*Euphorbia esula*). Emergent plants of major importance include purple loosestrife (*Lythrum salicaria*) and the common reed (*Phragmites australis*).

Major invasive animals in the Missouri River mainstem include Asian carp, common carp (*Cyprinus carpio*), Asian clams (*Corbicula fluminea*), rusty crawfish (*Orconectes rusticus*), quagga mussels (*Dreissena rostriformis*), and zebra mussels (*Dreissena polymorpha*). Asian carp are various species of carp in the family Cyprinidae. Bighead carp (*Hypophthalmichthys nobilis*), black carp (*Mylopharyngodon piceus*), grass carp (*Ctenopharyngodon idella*), and silver carp (*Hypophthalmichthys molitrix*) are the main species of Asian carp that inhabit the Missouri River as invasive species (Galat et al. 2004). Common carp is also a main invasive species. All of them are large-bodied fishes that can become quite heavy, sometimes exceeding 80 pounds, and all of them are primarily planktivorous (Conover et al. 2007). Asian carp are planktivorous and may compete with native planktivores for food, particularly considering that Asian carp are highly efficient feeders (Nico and Fuller 2010). Native species possibly threatened include paddlefish (*Polydon spathula*), bigmouth buffalo (*Ictiobus cyprinellus*), and gizzard shad (*Dorosoma pretenense*), as well as several others (Nico and Fuller 2010). A number of other invasive animals of concern could cause problems in the in the area where management actions would occur in the future.

Emerald ash borer (*Agrillus planipennis*) has been reported in several counties in Missouri and Iowa, and was confirmed in Nebraska in 2016 near Omaha, Nebraska (USDA 2016). In addition, there are other various insect species that have not yet appeared but that may pose a threat to tree populations: European gypsy moth (*Lymantria dispar*), red turpentine beetle (*Dendroctonus valens*), ips beetle (*Ips confusus*), and mountain pine beetle (*Dendroctonus ponderosae*).

3.5.1.8 Commercial Fisheries

Commercial fishing on the Missouri River is regulated by the relevant state fish and wildlife agency. The State of Missouri has been collecting data on commercial fishing within Missouri waters since 1945 and provides the basis for the information presented here. The number of commercial permits issued and the number of licensed commercial fishers that harvested fish has generally declined (Tripp et al. 2012). From 2000 to 2012, commercial fish harvest on the Missouri River in Missouri averaged 173,444 pounds comprising 34 percent of the total reported commercial harvest in the state. Buffalofishes, carp, and Asian carp were the top three species groups by total pounds commercially harvested from 2000 to 2012. The exception was that shovelnose sturgeon ranked in the top three in two years over that timeframe. Shovelnose sturgeon harvest on the Missouri River peaked in 2001 at 12,595 pounds before dropping to zero following the 2010 Similarity of Appearance provision of the ESA, which closed commercial fishing for shovelnose sturgeon in the Missouri River (Tripp et al. 2012). Catfish harvest has been prohibited on the Missouri River in Missouri since 1992.

3.5.1.9 Tribal Resources

Many of the plant and animal species associated with the habitat classes modeled are of great importance to Tribes. The importance of these species varies but includes use in ceremonies, medicines, and subsistence. Species include cottonwood trees, sage, chokecherries, willow trees, and others. Hunting and fishing were common practices by Tribes and still continue to a lesser degree. Additional information on the importance of fish and wildlife to Tribes is included in the Section 3.20, Tribal Interests (Other).

3.5.2 Environmental Consequences

Management actions could affect native terrestrial and aquatic habitats and changes in these habitats could affect native fish and wildlife. Altered abundance of terrestrial and aquatic habitat classes and reduced availability of these communities could have adverse effects on native fish and wildlife, which would correspond to greater changes and reductions in the abundance and types of native fish and wildlife species. The environmental analysis for fish and wildlife focused on changes in terrestrial and aquatic habitat. For the analysis of impacts to fish and wildlife, this section considers the actions included under each alternative and their impacts to fish and wildlife habitats. This section includes the methodology for analyzing impacts on fish and wildlife and the results of the analysis.

3.5.2.1 Impacts Assessment Methodology

Impacts were analyzed based on anticipated changes in habitat under each alternative compared to habitat conditions under Alternative 1. Changes in habitat associated with the proposed management actions under each of the six alternatives were estimated based on modeling results. The modeling process, including the methodology and detailed results, are summarized in Section 3.5.1, Affected Environment, and in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org). 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 (refer to the H&H Technical Reports available online at www.moriverrecovery.org). Because it is not possible to separate the impacts from different flow operations modeled under any alternative and discuss them individually, all flow actions modeled under each of the alternatives are considered together as

having one overall impact to each fish and wildlife habitat class and the associated assemblages and taxa.

Impacts on fish and wildlife not related to flow management actions (e.g., mechanical ESH construction and channel reconfiguration for construction of early life stage pallid habitat) are evaluated qualitatively and are based on the type and magnitude of impact for each management action under each alternative. The fish and wildlife species that depend on aquatic and terrestrial habitats are evaluated based on assemblages or groups of species associated with the individual or multiple aquatic and terrestrial habitat classes, wetland classes, or depth classes. Examples of the physical and biological functions of these habitats are discussed in the Affected Environment section. Impacts from invasive species are assessed qualitatively based on the potential for their introduction or spread from any of the management actions.

The HEC-EFM, HBC, and HAC models were used to estimate the average total number of frequency flows below 9,000 cfs overall and daily only in the Fort Randall and Gavins Point reach for the POR (82 years), as shown in Table 3-11.

The No Action Alternative is considered the baseline against which the other alternatives are measured. Under the No Action Alternative, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, the No Action Alternative does 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.

Table 3-11. Flow Occurrences Below 9,000 cfs in the Fort Randall to Gavins Point Reach

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Total Number of Flow Occurrences <9,000 cfs	150,508	161,248	150,030	155,588	152,620	153,182
Average Number of Flow Occurrences <9,000 cfs per day	4.97	5.33	4.96	5.14	5.04	5.06

3.5.2.2 Summary of Environmental Consequences

Table 3-12 summarizes the impacts of each alternative to fish and wildlife. 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.

Each alternative consists of management actions designed to benefit piping plovers, least terns, and pallid sturgeon; however these actions would also provide benefit to a wide variety of other Missouri River fish and wildlife species. A net increase in aquatic and terrestrial fish and wildlife

habitat would occur under each alternative. In addition to the analysis described in this MRRMP-EIS, past NEPA documents prepared by the USACE have described the significant benefits of increasing and diversifying fish and wildlife habitat on the Missouri River. The two main documents include the Missouri River Bank Stabilization and Navigation Project Final Feasibility Report and Final EIS (USACE 1981) and the Missouri River Fish and Wildlife Mitigation Project Final Supplemental EIS (USACE 2003a).

Table 3-12. Environmental Consequences Relative to Fish and Wildlife

Alternative	Impacts to Fish and Wildlife
Management Actions Common to All Alternatives	• Overall, adverse impacts to fish and wildlife from impacts of management actions common to all alternatives would be temporary. Negligible and small impacts from vegetation and predator management activities and the introduction or establishment of invasive species could occur. • Beneficial impacts from human restriction measures could occur by protecting other non-target wildlife species.
Alternative 1	• Overall, adverse impacts would be temporary. Negligible to small impacts to fish and wildlife would occur from habitat construction management actions during construction. • Long-term large beneficial impacts on fish and wildlife would occur from habitat construction management actions that would provide habitat for a variety of wildlife species.
Alternative 2	• Overall, adverse impacts would be temporary. Negligible to large impacts to fish and wildlife would occur from habitat construction management actions during construction. • Compared to Alternative 1 large impacts would occur to aquatic habitat due to the magnitude of acres of ESH construction. • Compared to Alternative 1 overall long-term beneficial large impacts would occur from habitat construction management actions that would provide habitat for a variety of wildlife species with substantially more habitat created under Alternative 2.
Alternatives 3−6	• Overall, adverse impacts would be temporary. Negligible to small adverse impacts would occur similar to Alternative 1. • Compared to Alternative 1 beneficial impacts would be negligible to small from habitat construction management actions that would provide habitat for a variety of wildlife species under Alternatives 3−6.

Environmental Quality

Human considerations for fish and wildlife are evaluated under the EQ account which displays the non-monetary effect on significant natural and cultural resources.

The fish and wildlife results are presented in Figure 3-31 through Figure 3-37. Results are presented as change in area (acres) compared to Alternative 1 and represent the change in habitat composition for the median or typical hydrologic condition in all study reaches over the POR (82 years) for each alternative. EQ account results are presented as percent change compared to Alternative 1 as modeled in all study reaches for the POR. The wetland habitat classes are not shown separately under individual alternative discussions but are included in results for the fish and wildlife habitat classes. Detailed EQ account results, including absolute acres under each alternative for each habitat class and depth class within each study reach, can be found in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

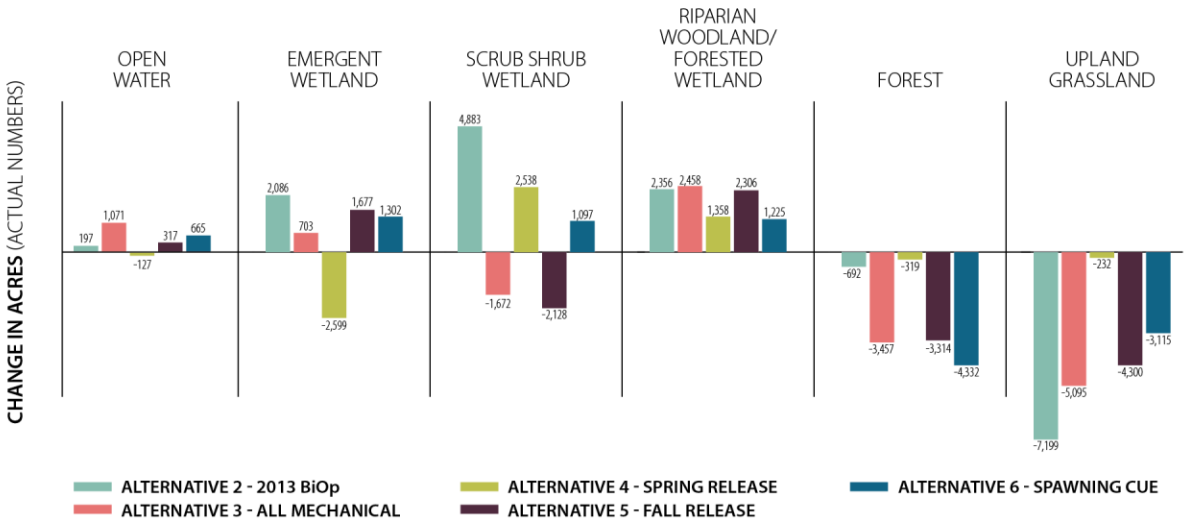


Figure 3-31. Overall Change from Alternative 1 in Fish and Wildlife Habitat Classes

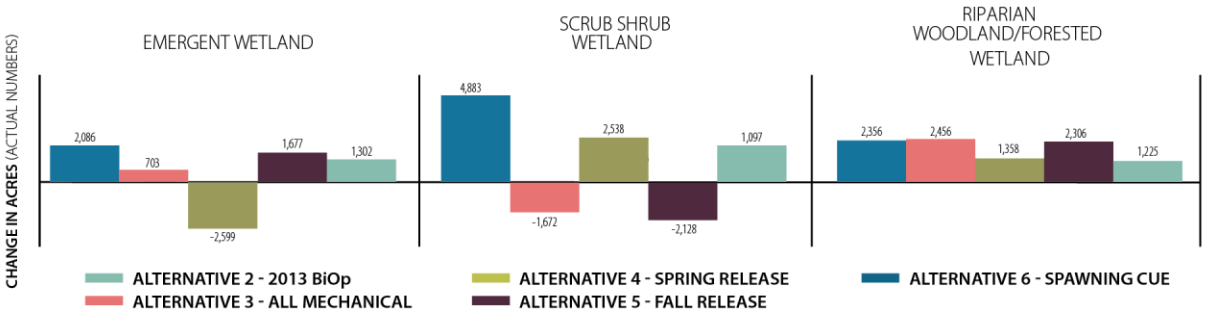


Figure 3-32. Overall Change from Alternative 1 in Wetland Habitat Classes

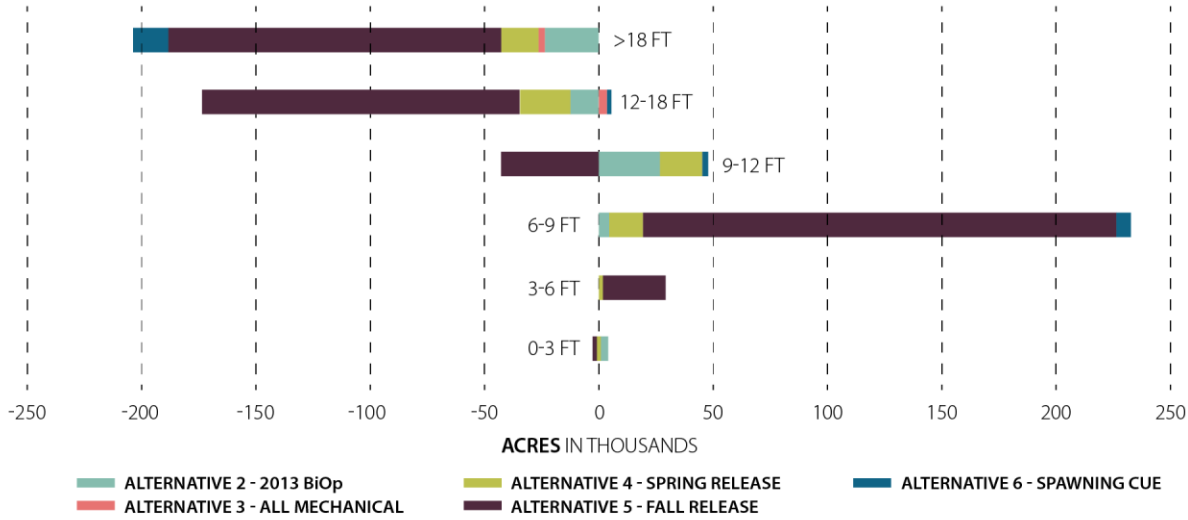


Figure 3-33. Overwintering Late Period Overall Change from Alternative 1 in Acres of Depth Classes

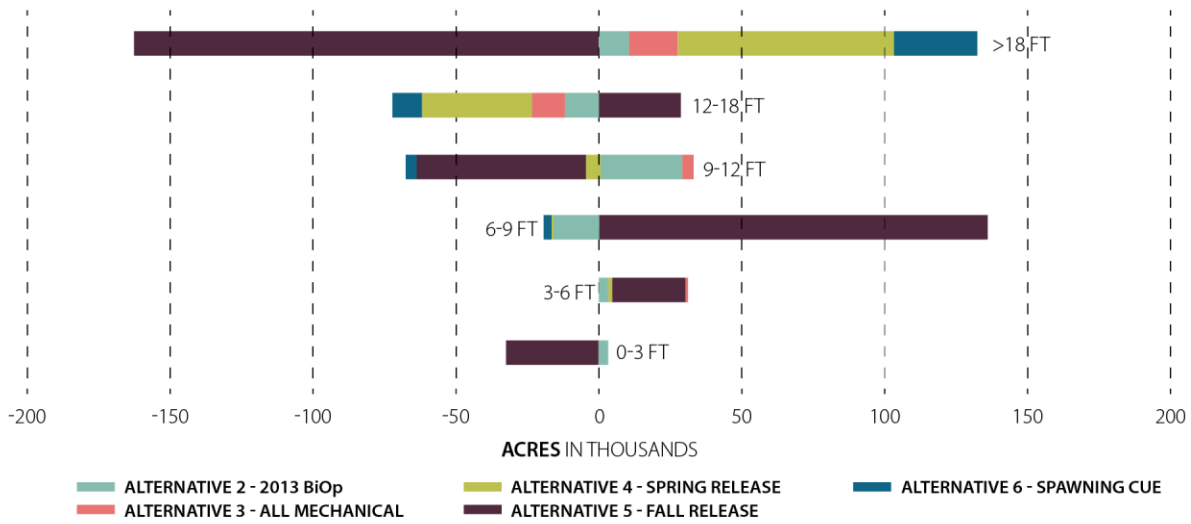


Figure 3-34. Early Spawning Period Overall Change from Alternative 1 in Acres of Depth Classes

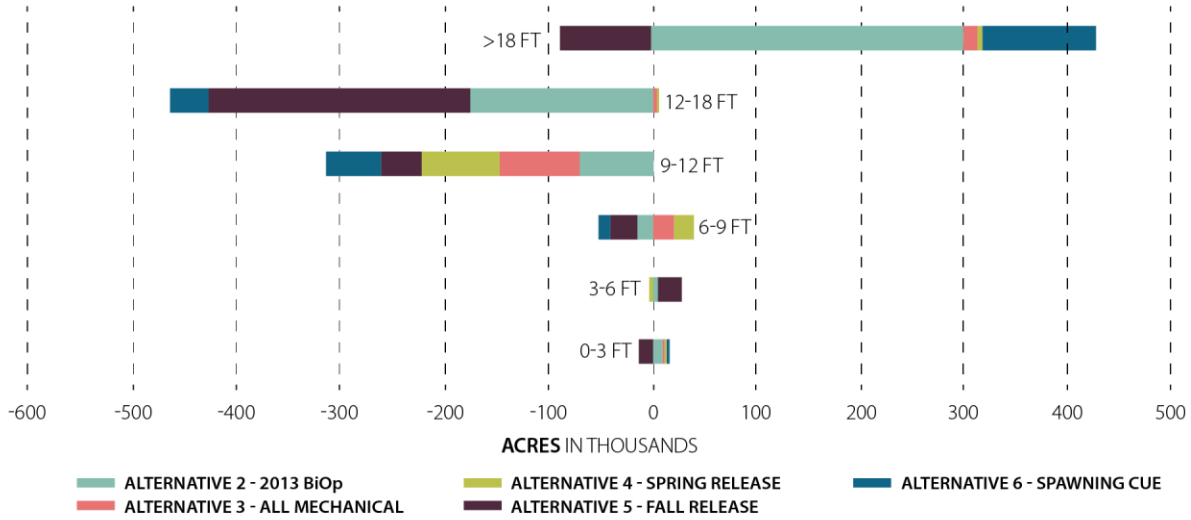


Figure 3-35. Late Spawning Period Overall Change from Alternative 1 in Acres of Depth Classes

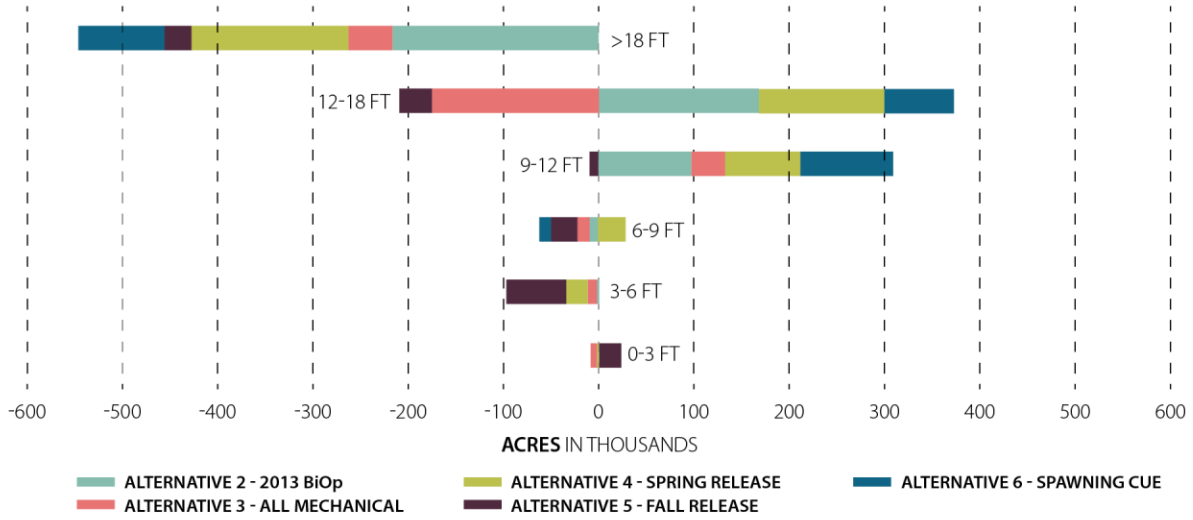


Figure 3-36. Summer Rearing Period Overall Change from Alternative 1 in Acres of Depth Classes

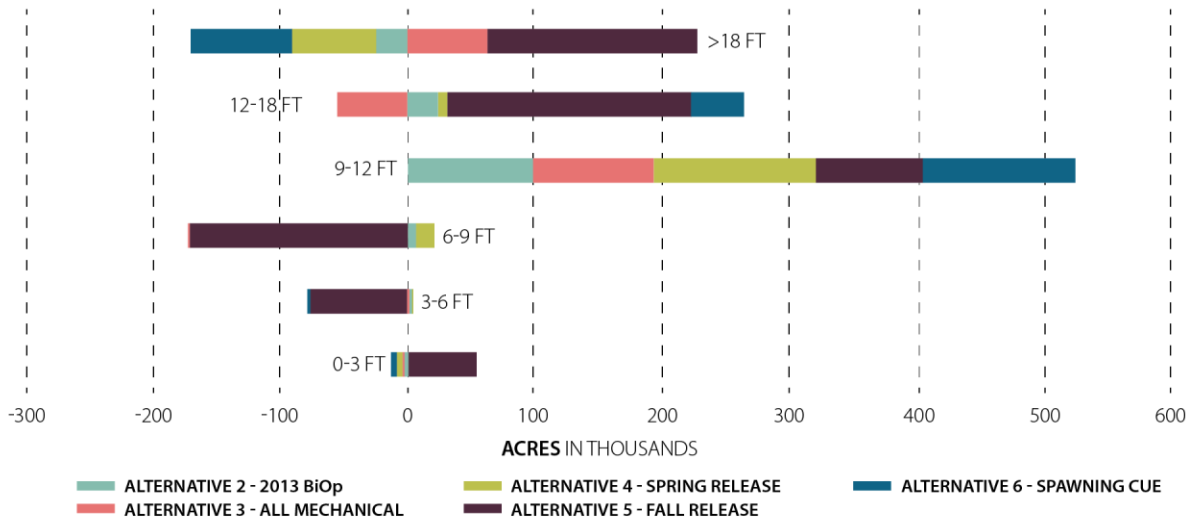


Figure 3-37. Overwintering Period Overall Change from Alternative 1 in Acres of Depth Classes

3.5.2.3 Impacts from Management Actions Common to All Alternatives

Vegetation Management, Predator Management, and Human Restriction Measures

Impacts to fish and wildlife from vegetation management would be temporary and small (USACE 2011 [ESH PEIS]). Although herbicides could enter the substrate when vegetation is removed during vegetation management operations, only herbicides approved by the EPA for aquatic use would be applied at the recommended rates. Potential indirect impacts to birds, small and large mammals, and invertebrate species from herbicide spraying could occur due to changes in vegetation composition. As additional habitat is created for fish and wildlife from mechanical ESH construction, any potential incremental increase to herbicide exposure would

result in small adverse temporary impacts to fish and wildlife. Most activities would occur on sandbars in the river, thus, the risk from herbicide use to non-target vegetation would be minimal.

Impacts from predator management would occur to individual wildlife species if lethally removed. However, lethal predator management is not expected to result in any adverse impacts to the overall population levels of any target species. Species that are targeted for lethal removal are widespread and abundant within the region. There could be temporary impacts to wildlife during placement of human restriction barricades or signs from disturbance to wildlife in the area. However, excluding human access from least tern and piping plover nesting and brood rearing sites would also protect other wildlife and fish species. Therefore, human restriction measures would result in negligible impacts to fish and wildlife (USACE 2011 [ESH PEIS]).

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

Environmental Quality

The results of modeled habitat under typical hydrologic conditions for the fish and wildlife habitat classes, wetland habitat classes, depth classes, and flow occurrences below 9,000 cfs under Alternative 1 are included in Table 3-13, Table 3-14, and Figure 3-38.

Fish and Wildlife Habitat Classes and Wetland Habitat Classes

The acres of habitat under Alternative 1 modeled overall in all study reaches for the POR (82 years) from highest to lowest include open water (213,527 acres), scrub shrub wetland (94,408 acres), upland grassland (63,768 acres), emergent wetland (46,938 acres), forest (26,162 acres), and riparian woodland/forest (23,891 acres). Table 3-13 and Figure 3-38 show acres within each habitat class and acres within each wetland class for each of the river reaches under Alternative 1.

Depth Classes

The acres within each depth class for each period for Alternative 1 are used as a comparison of percent change for Alternatives 2 through 6. The acres of each depth class under Alternative 1 are presented in Table 3-14.

Table 3-13. Total Acres of Modeled Fish and Wildlife Habitat Classes under Alternative 1

Habitat Types	Modeled Acres of Habitat by River Reach								
	Fort Peck to Garrison	Garrison to Oahe	Fort Randall to Gavins Point	Gavins Point to Rulo	Rulo to Kansas River	Kansas River to Grand River	Grand River to Osage River	Osage River to Mississippi River	Total
Open Water	62,929	62,476	8,927	26,588	10,700	12,127	12,978	16,801	**213,526**
Emergent Wetland	9,044	13,030	5,031	7,710	2,475	2,803	3,657	3,189	**46,939**
Scrub Shrub Wetland	56,758	11,608	13,822	3,799	1,131	1,287	2,271	3,733	**94,409**
Riparian Woodland/Forested Wetland	19,369	539	1,215	386	146	418	480	1,337	**23,890**
Forest	14,913	4,174	2,620	551	292	664	1,181	1,767	**26,162**
Upland grassland	22,796	8,808	3,297	710	6,701	4,634	8,402	8,420	**63,768**
Total	**185,809**	**100,636**	**34,912**	**39,743**	**21,445**	**21,934**	**28,969**	**35,246**	**468,694**

Table 3-14. Modeled Acres of Depth Classes for Alternative 1

Study Reach and Depth Class		Modeled Acres of Depth Classes				
		Overwintering Late	Early Spawning	Late Spawning	Summer Rearing and Growth	Overwintering Early
Fort Peck to Garrison	0–3 feet	119,549	118,892	151,065	120,704	100,667
	3–6 feet	170,378	173,262	115,432	167,311	193,434
	6–9 feet	221,793	274,496	189,730	223,707	356,934
	9–12 feet	349,934	400,025	382,191	277,449	225,807
	12–18 feet	405,837	301,276	519,973	392,911	279,709
	>18 feet	217,286	207,776	260,752	214,744	195,680

Study Reach and Depth Class		Modeled Acres of Depth Classes				
		Overwintering Late	Early Spawning	Late Spawning	Summer Rearing and Growth	Overwintering Early
Garrison to Oahe	0–3 feet	70,617	70,886	70,520	70,588	68,247
	3–6 feet	78,117	80,464	82,246	82,198	87,843
	6–9 feet	136,958	133,857	120,075	120,059	164,645
	9–12 feet	212,446	191,852	189,620	190,602	228,462
	12–18 feet	364,270	380,093	390,649	389,953	360,648
	>18 feet	174,080	185,907	200,066	200,065	99,502
Fort Randall to Gavins Point	0–3 feet	13,702	18,373	21,503	28,589	21,331
	3–6 feet	31,013	23,825	22,350	22,726	22,364
	6–9 feet	41,322	21,039	22,424	17,692	23,430
	9–12 feet	43,599	39,272	31,329	20,120	31,153
	12–18 feet	60,409	83,894	83,661	94,130	83,471
	>18 feet	29,952	50,839	64,482	72,911	63,340
Gavins Point to Rulo	0–3 feet	13,400	19,965	23,361	22,081	21,059
	3–6 feet	22,076	14,824	18,091	17,811	15,064
	6–9 feet	196,976	18,178	11,818	12,285	19,338
	9–12 feet	881,215	197,735	111,425	85,538	152,989
	12–18 feet	2,149,128	1,625,096	1,138,703	1,054,652	1,514,812
	>18 feet	421,138	2,294,038	3,103,536	3,251,896	2,576,206
Rulo to Mouth of the Missouri River	0–3 feet	16,100	12,626	9,312	13,723	15,698
	3–6 feet	17,910	15,906	12,447	16,547	15,948
	6–9 feet	21,974	16,170	15,219	16,629	18,129
	9–12 feet	41,969	18,300	16,842	19,731	21,883
	12–18 feet	375,842	80,170	43,835	124,782	210,346
	>18 feet	254,900	632,280	729,005	578,114	481,749

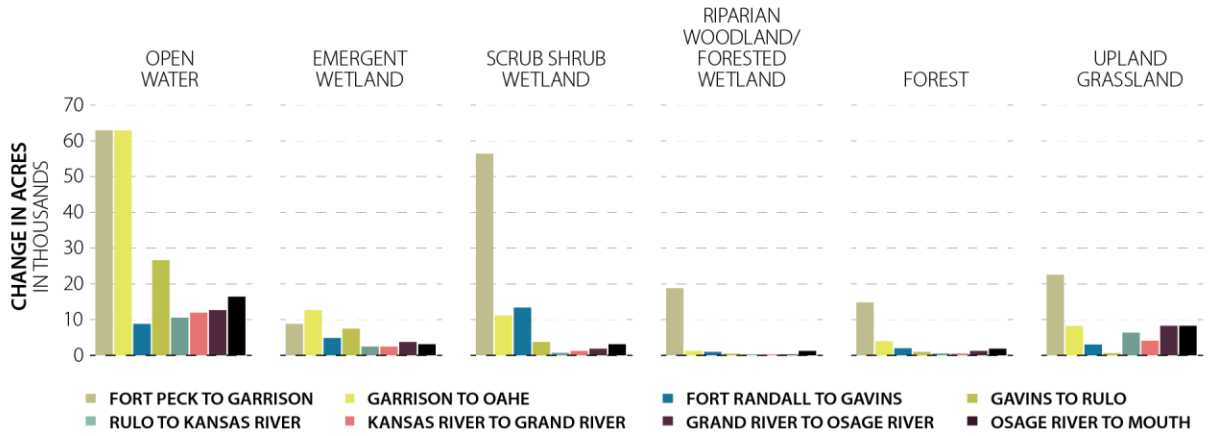


Figure 3-38. Modeled Acres of Fish and Wildlife Habitat Classes for Alternative 1

Flow Occurrences Below 9,000 cfs in the Fort Randall to Gavins Point Reach

There would be adverse impacts on fish and wildlife habitat classes and associated assemblages and taxa in the Fort Randall reach from flow occurrences below 9,000 cfs. The total number of flow occurrences below 9,000 cfs in the Fort Randall reach would be 150,508 for the POR and the average number of flow occurrences below 9,000 cfs per day would be 4.97, as modeled for the POR (82 years).

Mechanical ESH Construction

There could be negligible temporary impacts to fish and wildlife at locations where mechanical ESH construction would occur, including displacement and disruption of fish and wildlife. Mobile species of fish and wildlife would be expected to find refuge in nearby habitat until the end of construction disturbance. Construction-related impacts to fish and wildlife species (e.g., noise, vibration, and equipment emissions) within adjacent terrestrial or aquatic habitat would persist for the duration of annual construction [ESH PEIS]). Disturbance of fish and wildlife habitat classes from construction activities would mainly occur to those located within the channel or channel margins (i.e., open water, emergent wetland, and scrub-shrub wetland). Negligible impacts are expected to habitat classes on the floodplain or uplands (i.e., riparian woodland/forest, forest, and upland grassland) because ESH construction activities are primarily in-channel.

Mechanical ESH construction provides habitat for many wildlife species, including habitat for nesting and foraging. Shorebirds species other than the least tern and piping plover have been documented nesting on constructed ESH. The constructed ESH would potentially provide increased opportunities for breeding success of reptiles, as nesting success of turtles was found to be related to the use of sandbars and small islands. In addition, the majority of amphibian species have been spotted using the islands and sandbars within the river. Fisheries biologists have noted that submerged areas associated with sandbars provide rearing areas for a number of species (e.g., walleye, northern pike, emerald shiner, etc.) due to the shallower, warmer water with less current. These areas are thought to be crucial rearing areas for most species (USACE 2011 [ESH PEIS]). Given the acres of ESH construction these benefits would likely be small.

Spawning Cue Releases

Modeled flow actions included spawning cue releases, and as discussed earlier, all flow actions modeled are considered together as having one overall impact to fish and wildlife habitat classes.

Throughout the POR substantial variability in hydrologic conditions occurs which includes some periods of high runoff. Only a small amount of water compared to natural flow variability would be released during implementation of the spawning cue releases as discussed in Section 3.2 and the results are from all rules of current operation. Therefore, impacts of spawning cue releases on fish and wildlife under Alternative 1 are generally small compared to the impacts caused by the extreme hydrologic events in the POR. Long-term adverse impacts on fish and wildlife from degradation of the riverbed and streambank erosion, leading to changes in fish and wildlife habitat, would be negligible compared to existing conditions. Overall erosion and sediment transport processes are largely affected by natural precipitation and snowmelt events. The impacts on fish and wildlife under Alternative 1 from spawning cue releases would be negligible, occurring seasonally during years when downstream flow limits allow.

Channel Reconfiguration for Creation of Early Life Stage Pallid Habitat (SWH)

The construction of early life stage pallid habitat would occur only in the lower river from Ponca, Nebraska to the mouth of the Missouri River. Construction of early life stage pallid habitat, such as channel widening and construction of side channels and chutes, may require limited clearing of vegetation impacting fish and wildlife habitat. However, impacts would be minimized through clearing and grubbing of vegetation outside of important life history stages for selected species (e.g., primary migratory bird nesting season; active roosting of bat species). Channel widening and chute construction would result in the displacement of large amounts of overbank material from excavation required during construction and planned erosion of the bank that could result in impacts to fish and wildlife from temporary displacement or disturbance of resident wildlife. These impacts would be small due to the temporary nature of the activities and the availability of similar habitat surrounding most sites. Temporary impacts from disturbance to fish in construction areas would be negligible due to the small areal extent of the work and the mobility of fish.

Construction of early life stage pallid habitat could cause conversion from terrestrial habitat to aquatic habitat (i.e., upland grassland to emergent wetland). An overall conversion of terrestrial habitat (e.g., forest, upland grassland) to aquatic habitat (e.g., open water, emergent wetland) could impact species dependent on terrestrial habitat. However, species that are dependent on aquatic habitat would benefit. The scale of proposed early life stage pallid habitat and the potential conversion of terrestrial habitat to aquatic habitat would be negligible compared to the amount of terrestrial habitat available on the Missouri River. The majority of vegetation adjacent to the mainstem river is agricultural and high quality terrestrial habitats would not be removed for construction of early life stage pallid habitat. The addition of aquatic habitat that would attract species that use these habitats (e.g., aquatic furbearers) could increase the diversity once a project is complete. Increased wetted shoreline habitat should benefit wading birds and shorebirds that use sandbars and mudflats during the migratory period. Songbirds that nest and bats that roost in forested areas or areas adjacent to forested areas may be temporarily disturbed; however, all tree and shrub removal would be scheduled to take place outside of the nesting or roosting period.

Early life stage pallid habitat could also benefit a number of other fish species. Most riverine fish depend on low-velocity, shallow water habitat at some point in their life history. Several species (e.g., paddlefish, shovelnose sturgeon) spawn in such habitat, and the juveniles of most species rear in low-velocity regions until they are large enough to maintain themselves in the Missouri River main channel. Many species spend their entire life in the low-velocity areas of the river. Backwaters, side channels, and other low-velocity habitat are currently limited in some of the remaining river reaches. Construction of these habitats would have long-term, large, beneficial impacts to fish and wildlife.

The acres and extent of implementation of channel configuration for construction of early life stage pallid habitat varies by alternative, however, the type and duration of impacts would be similar.

Habitat Development and Land Management on MRRP Lands

Habitat development and land management on MRRP lands would result in the acquisition and development of areas for fish and wildlife habitat. The USACE must typically purchase enough land from willing sellers to accommodate the habitat project and provide a buffer between the project and adjacent lands. This additional land would be used for habitat development that would benefit fish and wildlife species in the long term. Any adverse construction-related impacts to fish and wildlife habitat would be small. Habitat development and land management would result in large long-term beneficial impacts to fish and wildlife habitat. The scale (i.e., acres) of land acquisition and extent of implementation of habitat development and land management on MRRP lands would vary under each alternative but impacts would be similar.

Conclusion

Overall, adverse impacts to fish and wildlife from impacts of management actions under Alternative 1 would be temporary and construction related. Negligible to small adverse impacts from vegetation and predator management activities could occur. In the upper river, human restrictions measures would benefit fish and wildlife by protecting other non-target species although these benefits would be negligible at the regional level. Habitat construction management actions that would provide habitat for a variety of wildlife species would have large long-term benefits. Alternative 1 would not have significant adverse impacts on fish and wildlife because adverse impacts would be temporary and negligible to small.

3.5.2.5 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Environmental Quality

The modeling results for fish and wildlife habitat classes and wetland habitat classes under Alternative 2 are shown in Figure 3-39 and Figure 3-40. The change in acres for each metric from the implementation of flow related management actions under Alternative 2 compared to Alternative 1, including spawning cue releases and a low summer flow from Gavins Point, are summarized in the following sections.

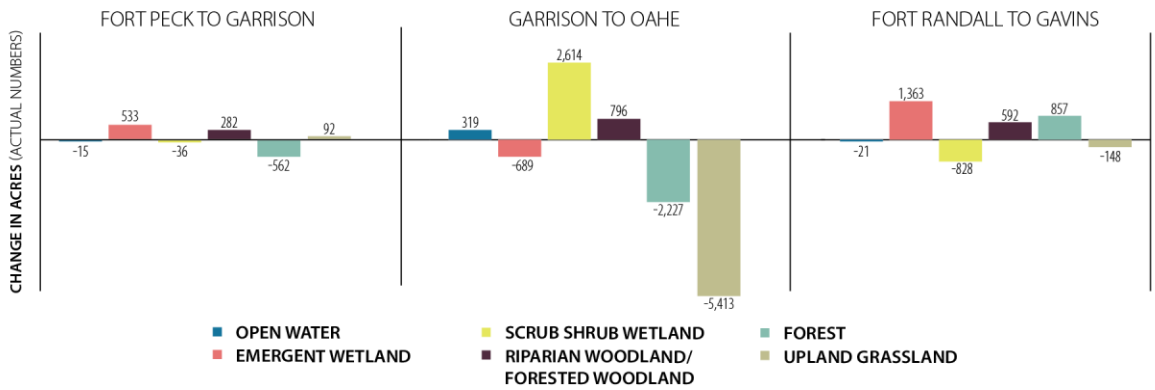


Figure 3-39. Modeled Change in Acres of Fish and Wildlife Habitat Classes Compared to Alternative 1 – Upper River

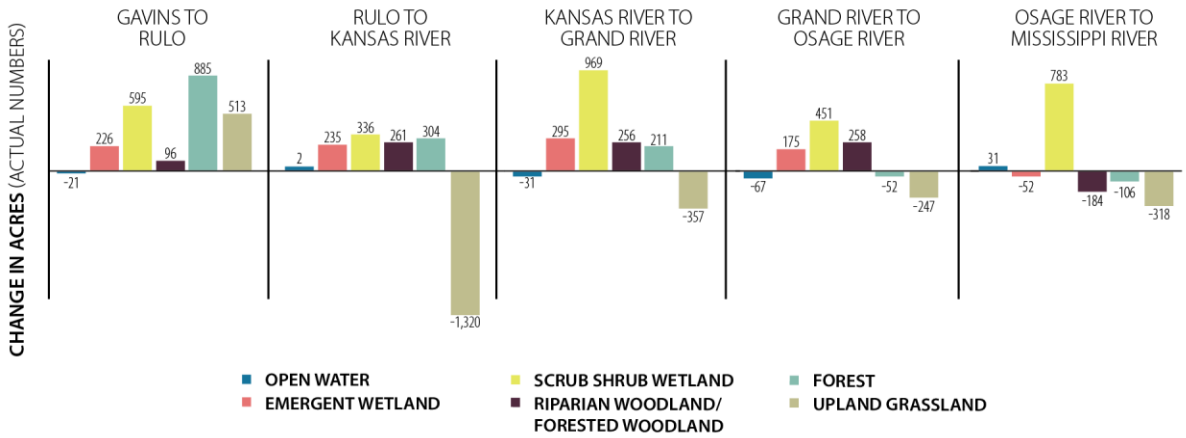


Figure 3-40. Modeled Change in Acres of Fish and Wildlife Habitat Classes Compared to Alternative 1 – Lower River

Fish and Wildlife Habitat Classes and Wetland Habitat Classes

Compared to Alternative 1, the riparian woodland/forested wetland habitat class under Alternative 2 would have an increasing trend. Open water, emergent wetland, and scrub shrub wetland would also have an increasing trend and forest and upland grassland would have a decreasing trend as modeled.

Depth Classes

For all river reaches combined, the 0–3, 3–6, 6–9, and 9–12 foot depth classes would have an increasing trend in the overwintering late period. The 0–3, 3–6, 9–12, and greater than 18 foot depth classes would have an increasing trend in the early spawning period. The 0–3, 3–6, and greater than 18 foot depth classes would have an increasing trend in the late spawning period. The 0–3, 3–6, 9–12, and 12–18 foot depth classes would have an increasing trend in the summer rearing and growth period. The 3–6, 6–9, 9–12, and 12–18 foot depth classes would have an increasing trend in the overwintering early period. These increases would benefit

species that use the depth classes during a specific period. Adverse impacts could occur to species that require depth classes that decrease during a specific period (Figure 3-39 and Figure 3-40). A summary of the trend in depth classes within each of the eight study reaches follows. More information regarding the depth classes can be found in the "Fish and Wildlife Environmental Consequences Analysis Technical Report" available online (www.moriverrecovery.org).

Upper River

Fort Peck to Garrison: The 9–12 foot depth class would have the greatest increasing trend (40.9 percent) during the overwintering early period and the 9–12 foot depth class would have the greatest decreasing trend (13.7 percent) in the late spawning period.

Garrison to Oahe: The 9–12 foot depth class would have the greatest increasing trend (5.9 percent) during the early spawning period and the 6–9 foot depth class would have the greatest decreasing trend (9.9 percent) in the late spawning period.

Fort Randall to Gavins Point: The 9–12 foot depth class would have the greatest increasing trend (24.3 percent) during the overwintering early period and the 9–12 foot depth class would have the greatest decreasing trend (20.7 percent) in the late spawning period.

Lower River

Gavins Point to Rulo: The 0–3 foot depth class would have the greatest increasing trend (19.5 percent) during the late spawning period and the 9–12 foot depth class would have the greatest decreasing trend (19.4 percent) in the late spawning period.

Rulo to Mississippi River: The 0–3 foot depth class would have the greatest increasing trend (26.0 percent) during the late spawning period and the 12–18 foot depth class would have the greatest decreasing trend (7.8 percent) in the late spawning period.

Flow Occurrences Below 9,000 cfs in the Fort Randall to Gavins Point Reach

The total number of flow occurrences and the average number per day below 9,000 cfs in the Fort Randall reach would have an increasing trend under Alternative 2 compared to Alternative 1 as modeled for the POR (82 years). Therefore, negligible impacts would be assumed to occur to fish and wildlife habitat and associated assemblages and taxa in the Fort Randall reach compared to Alternative 1.

Mechanical ESH Construction

Under Alternative 2, an average of 3,546 acres of ESH would be constructed annually, 3,439 more acres per year compared to Alternative 1. While greater adverse impacts would occur during ESH construction under Alternative 2 compared to Alternative 1, greater beneficial impacts would occur as well. Under Alternative 2 these impacts would also occur in the Fort Randall and Lewis and Clark Lake reaches.

Disturbance of vegetation due to construction activities is anticipated to be low. Site-specific pre-construction surveys would be conducted to avoid or minimize impacts to wetlands and other sensitive habitats. Wetland impacts from mechanical ESH construction in the Fort Randall and Gavins Point reaches could occur during construction but would be small. The 2011 ESH

PEIS states that mechanical ESH construction in the Garrison reach would likely cause large losses of existing wetlands from the high level of habitat construction required under Alternative 2. The differences in these impacts would be small overall and would result in a small change to the resource condition compared to Alternative 1 in the regional context.

Dredging required annually under Alternative 2 to create ESH could result in large impacts to fish and wildlife aquatic habitats and associated taxa. Dredging would suspend large quantities of silt and sediment throughout the reach beginning in mid-September. This annual suspension of silt would affect the last 2–3 months of the growing season by limiting photosynthesis. This annual reduction in primary productivity for plankton, hydrophytes, and vascular plants could diminish the vigor of existing wetlands and submerged aquatic vegetation leading to changes in species abundance and diversity over time. The impacts to primary productivity, submerged aquatic vegetation, and wetland vegetation could lead to a decline in the forage base and habitat quality for fish and wildlife (USACE 2011 [ESH PEIS]). Impacts from increased turbidity could occur from high concentration of fine-grained, inorganic particles that smother streambed and bank habitats and could cause damage to gill structures. Reduced light penetration may reduce the growth of aquatic plants, affecting food, cover, and daily oxygen production. On the other hand, an increase in turbidity may be beneficial to some native species because turbidity in the Missouri River has decreased dramatically since the construction of the dams (USACE 2011 [ESH PEIS]). Additionally, the increase in mechanical ESH construction could provide substantial habitat for many wildlife species with long-term, large, and beneficial impacts on fish and wildlife compared to Alternative 1.

Channel Reconfiguration for Creation of Early Life Stage Pallid Habitat (SWH)

The impacts from channel reconfiguration for construction of early life stage pallid habitat under Alternative 2 would be the same as Alternative 1 except for the magnitude of impact due to a greater amount of proposed number of acres. Under Alternative 2, 10,758 acres of early life stage habitat would be created in the lower river from Ponca, Nebraska to the mouth of the Missouri River. Compared to Alternative 1, 6,759 more acres of early life stage habitat would be created. While greater potential for adverse impacts would occur during construction compared to Alternative 1, more beneficial impacts would occur as well. The difference in these impacts would be small and would result in a small change to the resource condition compared to Alternative 1 in the regional context. On a smaller scale, large long-term benefits could occur from adding aquatic habitat diversity.

Spring Pallid Sturgeon Flow Release

While the releases under both Alternative 1 and Alternative 2 would be bimodal (i.e., consisting of two separate flow pulses), the conditions and characteristics of these flows would differ and are based on slightly different System requirements. However, the temporary adverse impacts from implementation of the releases under Alternative 2 would be relatively small, similar to those described for Alternative 1. Long-term, beneficial impacts on fish and wildlife could occur if hydrology provided in channel margins, off-channel areas, and floodplain areas allows the creation of early successional plant communities including wetland habitat. Construction of fish and wildlife habitat would result in a long-term, net increase in native vegetation and fish and wildlife habitat in localized areas.

Low Summer Flow

Native fish in the river reaches are naturally adapted to warm, muddy high spring and early summer flows and also to the late summer and fall flow characteristics of the historic Missouri River. Most riverine fish depend on low-velocity, shallow water habitat at some point in their life history. Several species spawn in such habitat, and the juveniles of most species rear in low-velocity regions until they are large enough to maintain themselves and avoid predation in the higher velocity flows of the Missouri River's main channel. Many species spend their entire life in the low-velocity areas of the river. Backwaters, side channels, and other low-velocity habitat are currently limited in some of the remaining river reaches. Implementation of low summer flows under Alternative 2 would create habitat for rearing, refugia, and foraging areas for larval, juvenile, and adult fish species. Impacts from low summer flows on fish and wildlife could be large in years when low summer flows could be implemented.

Floodplain Connectivity

USACE coordinated with USFWS during alternatives development to identify criteria for clarification of the floodplain connectivity management action for Alternative 2. These criteria were included in a Planning Aid Letter submitted to USACE on November 5, 2015. The criteria 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. USACE conducted HEC-GeoRAS mapping to determine the acres of existing floodplain connectivity in the lower Missouri River. The mapping results indicated that 156,480 acres of floodplain connectivity are currently present, not including the area of the main channel. Under Alternative 2, it is assumed that operations would result in floodplain connectivity of at least 77,410 acres, as indicated by the mapping results described previously, providing appropriate habitat for spawning and larval development for Missouri River native fishes. Beneficial impacts to fish and wildlife would continue long-term from floodplain inundation and connectivity.

Habitat Development and Land Management on MRRP Lands

The types of impacts related to habitat development and land management under Alternative 2 would be the same as Alternative 1 with the exception of the number of acres. Under Alternative 2, 33,648 more acres would be acquired for habitat development and land management compared to Alternative 1 resulting in a relatively large increase in benefits to fish and wildlife.

Conclusion

Overall, adverse impacts to fish and wildlife from impacts of management actions under Alternative 2 would be temporary and construction related. There would be an increasing trend towards wetter habitat classes such as emergent wetland, riparian woodland and forested wetland as modeled under Alternative 2 compared to Alternative 1. Negligible adverse temporary impacts from vegetation and predator management activities could occur. Large temporary construction related impacts would occur to aquatic habitat in the upper river due to the large magnitude of acres of ESH construction compared to Alternative 1. Long-term negligible impacts from human restriction measures could occur that would benefit fish and wildlife by protecting other non-target species. Adverse impacts from construction activity would range from negligible to large but would be temporary and localized. Therefore, Alternative 2 would not cause significant adverse impacts to fish and wildlife. Habitat construction management actions that would provide habitat for a variety of wildlife species would have large

long-term beneficial impacts with substantially more habitat created under Alternative 2 compared to Alternative 1.

3.5.2.6 Alternative 3 – Mechanical Construction Only

Environmental Quality

The modeling results for fish and wildlife habitat classes and wetland habitat classes under Alternative 3 are included in Figure 3-41 and Figure 3-42. The changes in acres for each metric from management actions under Alternative 3 compared to Alternative 1 are summarized in the following sections.

Fish and Wildlife Habitat Classes and Wetland Habitat Classes

Overall, under Alternative 3 compared to Alternative 1, the riparian woodland/forested wetland habitat class would have the greatest increasing trend. Open water and emergent wetland would also have an increasing trend and scrub shrub wetland, forest, and upland grassland would have a decreasing trend as modeled. The modeling results presented for fish and wildlife habitat and wetland habitat classes in each study reach are for the POR (82 years).

Depth Classes

For all river reaches combined, the 0–3, 3–6, 6–9, and 12–18 foot depth classes would have an increasing trend in the overwintering late period. The 3–6, 9–12, and greater than 18 foot depth classes would have an increasing trend in the early spawning period. The 0–3, 6–9, 12–18, and greater than 18 foot depth classes would have an increasing trend in the late spawning period. The 9–12 foot depth classes would have an increasing trend in the summer rearing and growth period. The 9–12 and greater than 18 foot depth classes would have an increasing trend in the overwintering early period. These increases would benefit species that use the depth classes during a specific period. Adverse impacts could occur to species that require depth classes that decrease during a specific period (Figure 3-41 and Figure 3-42). A summary of the trend in depth classes within each of the eight study reaches follows. More information regarding the depth classes can be found in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

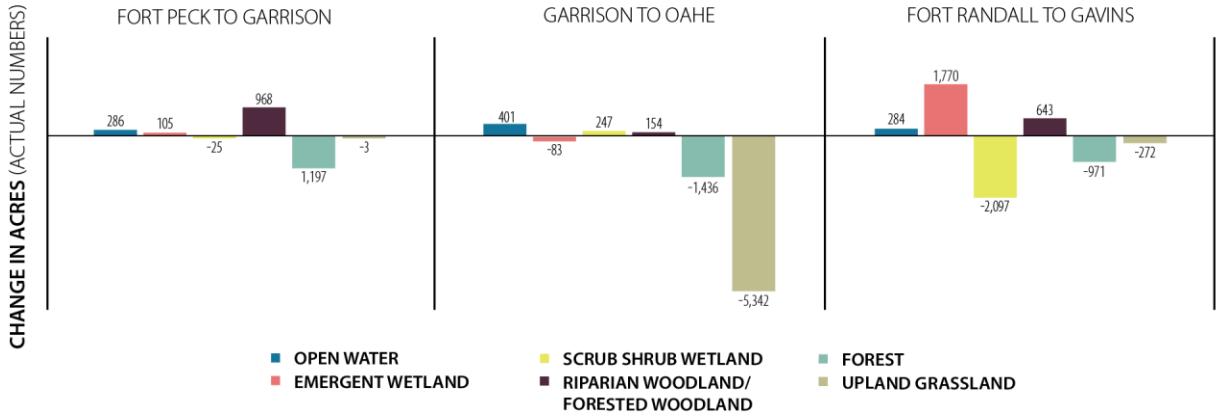


Figure 3-41. Modeled Change in Acres of Fish and Wildlife Habitat Classes Compared to

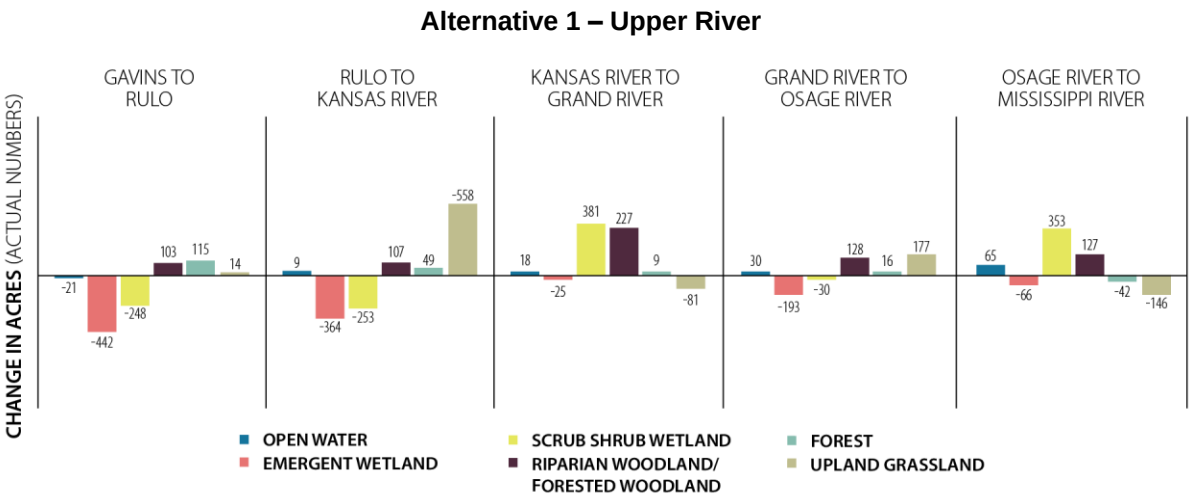


Figure 3-42. Modeled Change in Acres of Fish and Wildlife Habitat Classes Compared to Alternative 1 – Lower River

Upper River

Fort Peck to Garrison: The 9–12 foot depth class would have the greatest increasing trend (42.4 percent) during the overwintering early period and the 9–12 foot depth class would have the greatest decreasing trend (12.9 percent) in the late spawning period.

Garrison to Oahe: The 6–9 foot depth class would have the greatest increasing trend (12.1 percent) during the late spawning period and the 12–18 foot depth class would have the greatest decreasing trend (43.4 percent) in the summer rearing and growth period.

Fort Randall to Gavins Point: The 12–18 foot depth class would have the greatest increasing trend (13.2 percent) during the late spawning period and the 9–12 foot depth class would have the greatest decreasing trend (34.7 percent) in the late spawning period.

Lower River

Gavins Point to Rulo: The 6–9 foot depth class would have the greatest increasing trend (56.8 percent) during the late spawning period and the 9–12 foot depth class would have the greatest decreasing trend (9.6 percent) in the summer rearing and growth period.

Rulo to Mississippi River: The 0–3 foot depth class would have the greatest increasing trend (11.5 percent) during the late spawning period and the 3–6 foot depth class would have the greatest decreasing trend (6.8 percent) in the summer rearing and growth period.

Flow Occurrences Below 9,000 cfs in the Fort Randall to Gavins Point Reach

The total number of flow occurrences and the average number per day below 9,000 cfs in the Fort Randall reach would have a decreasing trend under Alternative 3 compared to Alternative 1 as modeled for the POR (82 years). Therefore, temporary beneficial negligible impacts would be assumed to occur to fish and wildlife habitat and associated assemblages and taxa in the Fort Randall reach compared to Alternative 1.

Mechanical ESH Construction

Under Alternative 3, an average of 391 acres of ESH would be constructed annually in years when construction is needed. Compared to Alternative 1, 284 more acres of ESH would be constructed annually in construction years. While slightly greater adverse impacts would occur during construction compared to Alternative 1 greater beneficial impacts would occur as well. The difference in these impacts would be small and would result in a small change to the resource condition compared to Alternative 1. The impacts from ESH construction under Alternative 3 in combination with the impacts common to all alternatives would be the same in intensity and duration as Alternative 1 but would also occur in the Fort Randall reach.

Spawning Habitat Construction

Spawning habitat for pallid sturgeon construction sites would be constructed in the lower river (i.e., Ponca, Nebraska to the mouth of the Missouri River) following initial studies to further clarify habitat specifications. Depending on the necessary features and site-specific resources there could be localized impacts to fish and wildlife during construction and maintenance. When high-quality spawning habitat is created, fish species other than pallid sturgeon would likely benefit from this habitat. These sites would be small compared to the area available to fish and wildlife for various functions within the Missouri River and, therefore, there would be negligible impacts on fish and wildlife and the resource condition would not be changed in the long term.

Channel Reconfiguration for Creation of Early Life Stage Pallid Habitat (IRC)

Channel reconfiguration for construction of early life stage habitat projects under Alternative 3 would occur in the lower river from Sioux City, Iowa to the mouth of the Missouri River and would be designed to meet the functional definitions of IRC. Construction of early life stage pallid habitat designed following the IRC is anticipated to be primarily accomplished through channel widening and/or structure modifications under Alternative 3. Under Alternative 3, up to 3,380 acres of new early life stage pallid habitat following the IRC would be created. Compared to Alternative 1, there would be 619 fewer acres of channel widening and no backwaters would be constructed. While slightly less adverse impacts would occur under Alternative 3 compared to Alternative 1, less beneficial impacts would occur as well. The difference in these impacts would be small and would result in a small change to the resource condition compared to Alternative 1.

Habitat Development and Land Management on MRRP Lands

The impacts of habitat development and land management under Alternative 3 would be the same as Alternative 1 except for the magnitude of impact due to fewer proposed acres. Under Alternative 3, 1,772 acres would be acquired. Compared to Alternative 1, 4,589 less acres would be acquired for habitat development and land management.

Conclusion

Overall, adverse impacts to fish and wildlife from impacts of management actions under Alternative 3 would be temporary and construction related. There would be an increasing trend towards wetter habitat classes such as forested wetland and riparian woodland as modeled under Alternative 3 compared to Alternative 1. Alternative 3 would not cause significant impacts to fish and wildlife given that adverse impacts would be temporary and negligible to small and long-term beneficial impacts would occur from habitat construction.

3.5.2.7 Alternative 4 – Spring ESH Creating Release

Environmental Quality

The results of the modeling of metrics for fish and wildlife habitat classes and wetland habitat classes under Alternative 4 are included in Figure 3-43 and Figure 3-44. The change in acres for each metric from the implementation of flow related management actions under Alternative 4 compared to Alternative 1, including a high Spring ESH-creating reservoir release for the least tern and piping plover from Gavins Point, Fort Randall, and Garrison are summarized in the following sections.

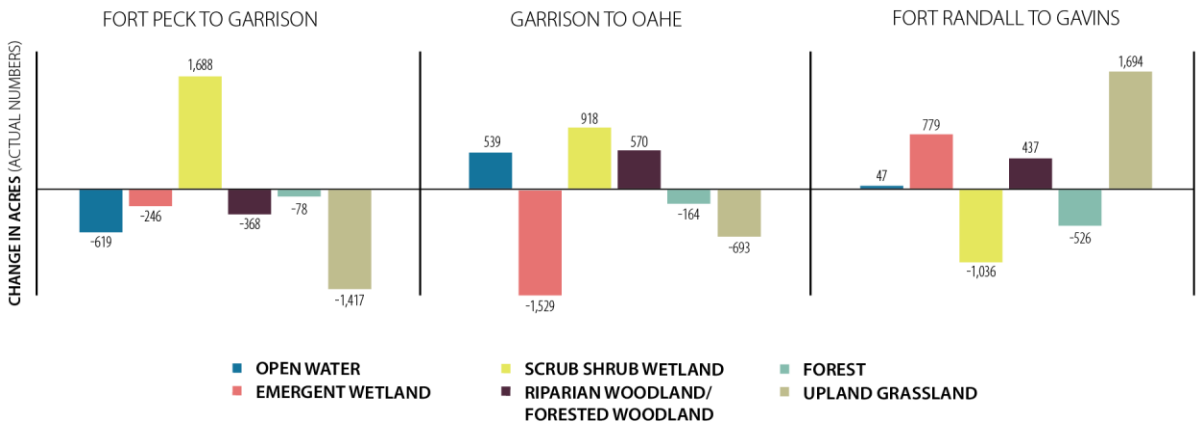


Figure 3-43. Modeled Change in Acres of Fish and Wildlife Habitat Classes Compared to Alternative 1 – Upper River

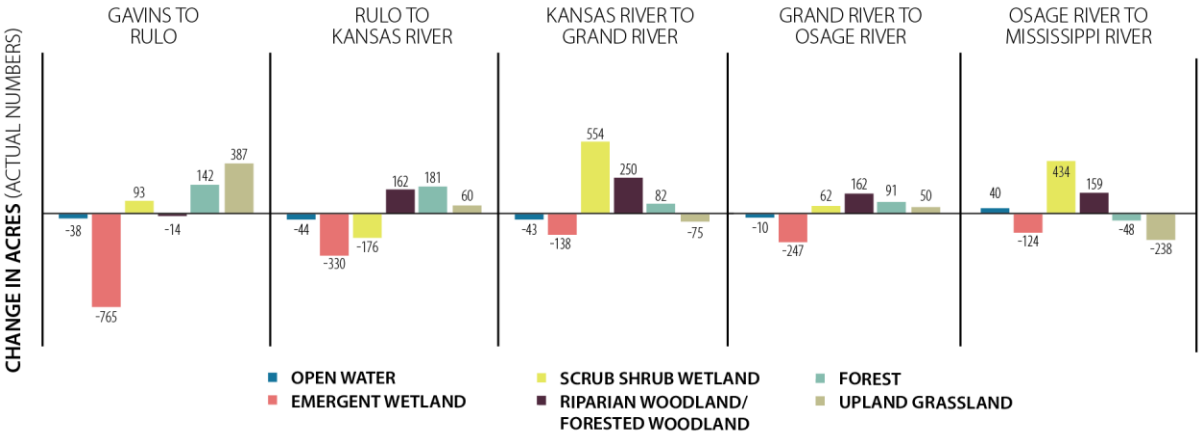


Figure 3-44. Modeled Change in Acres of Fish and Wildlife Habitat Classes Compared to Alternative 1 – Lower River

Fish and Wildlife Habitat Classes and Wetland Habitat Classes

Overall, under Alternative 4 the riparian woodland/forested wetland habitat class would have the greatest increasing trend compared to Alternative 1. Scrub shrub wetland also would have an increasing trend and open water, emergent wetland, forest, and upland grassland would have a decreasing trend as modeled.

Depth Classes

For all river reaches combined, the 6–9 and 9–12 foot depth classes would have an increasing trend in the overwintering late period. The 0–3, 3–6, and greater than 18 foot depth classes would have an increasing trend in the early spawning period. The 0–3, 6–9, 12–18, and greater than 18 foot depth classes would have an increasing trend in the late spawning period. The 0–3, 6–9, 9–12, and 12–18 foot depth classes would have an increasing trend in the summer rearing and growth period. The 3–6, 6–9, 9–12, and 12–18 foot depth classes would have an increasing trend in the overwintering early period. These increases would benefit species that use the depth classes during a specific period. Adverse impacts could occur to species that require depth classes that decrease during a specific period (Figure 3-43 and Figure 3-44). A summary of the trend in depth classes within each of the eight study reaches follows. More information regarding the depth classes can be found in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

Upper River

Fort Peck to Garrison: The 9–12 foot depth class would have the greatest increasing trend (42.1 percent) during the overwintering late period and the 9–12 foot depth class would have the greatest decreasing trend (14.8 percent) in the late spawning period.

Garrison to Oahe: The 6–9 foot depth class would have the greatest increasing trend (11.8 percent) during the summer rearing and growth period and the greater than 18 foot depth class would have the greatest decreasing trend (4.1 percent) in the late spawning period.

Fort Randall to Gavins Point: The 9–12 foot depth class would have the greatest increasing trend (24.2 percent) during the overwintering early period and the 9–12 foot depth class would have the greatest decreasing trend (34.8 percent) in the late spawning period.

Lower River

Gavins Point to Rulo: The 6–9 foot depth class would have the greatest increasing trend (55.9 percent) during the late spawning period and the 3–6 foot depth class would have the greatest decreasing trend (6.8 percent) in the summer rearing and growth period.

Rulo to Mississippi River: The 0–3 foot depth class would have the greatest increasing trend (8.7 percent) during the late spawning period and the 12–18 foot depth class would have the greatest decreasing trend (24.1 percent) in the late spawning period.

Flow Occurrences Below 9,000 cfs in the Fort Randall to Gavins Point Reach

The total number of flow occurrences and the average number per day below 9,000 cfs in the Fort Randall reach would have an increasing trend under Alternative 4 compared to Alternative 1 as modeled for the POR (82 years). Therefore, temporary adverse negligible impacts would

be assumed to occur to fish and wildlife habitat and associated assemblages and taxa in the Fort Randall reach compared to Alternative 1.

Mechanical ESH Construction

Under Alternative 4, an average of 240 acres of ESH would be constructed annually in years where construction is needed. Compared to Alternative 1, 133 more acres of ESH would be constructed. The impacts from ESH construction under Alternative 4 would be the same in intensity and duration as Alternative 1 but would also occur in the Fort Randall reach.

Spring Reservoir Release for ESH Creation

Flow releases would create habitat in the reaches of the upper river and along the lower river in Gavins Point and Ponca State Park reach. Habitat creation downstream of Ponca State Park would be minimal, due to the self-scouring nature of the channel, the gradual attenuation of the release of flows, and spawning cue releases with distance to Gavins Point Dam. Habitat creating flows of sufficient magnitude and duration would increase the area of fish and wildlife habitat on the river by increasing deposition, assuming sediment is available, thereby increasing the abundance and diversity of fish and wildlife species that use this habitat.

Any adverse impacts on fish and wildlife under Alternative 4 from spring reservoir release for ESH creation would be temporary, occurring seasonally during years when downstream flow limits allow. However, long-term, beneficial impacts could occur if the area of fish and wildlife habitat increases. Creation of fish and wildlife habitat would result in a long-term, net increase in native vegetation and fish and wildlife habitat in localized areas.

Spawning Habitat Construction

The impacts from spawning habitat construction under Alternative 4 would be the same as described for Alternative 3.

Channel Reconfiguration for Creation of Early Life Stage Pallid Habitat (IRC)

The impacts from channel reconfiguration for creation of early life stage pallid habitat (IRC) under Alternative 4 would be the same as described for Alternative 3.

Habitat Development and Land Management on MRRP Lands

The impacts from habitat development and land management under Alternative 4 would be the same as described for Alternative 3.

Conclusion

Overall, adverse impacts to fish and wildlife from impacts of management actions under Alternative 4 would be temporary and construction related. There would be an increasing trend towards wetter habitat classes such as forested wetland and riparian woodland as modeled under Alternative 4 compared to Alternative 1. Alternative 4 would not cause significant impacts to fish and wildlife given that adverse impacts would be temporary and negligible to small and long-term beneficial impacts would occur from habitat construction.

3.5.2.8 Alternative 5 – Fall ESH Creating Release

Environmental Quality

The modeling results for fish and wildlife habitat classes and wetland habitat classes under Alternative 5 are included in Figure 3-45 and Figure 3-46. The change in acres for each metric from the implementation of flow related management actions under Alternative 5 compared to Alternative 1, including a high fall ESH-creating reservoir release for the least tern and piping plover from Gavins Point, Fort Randall, and Garrison are summarized in the following sections.

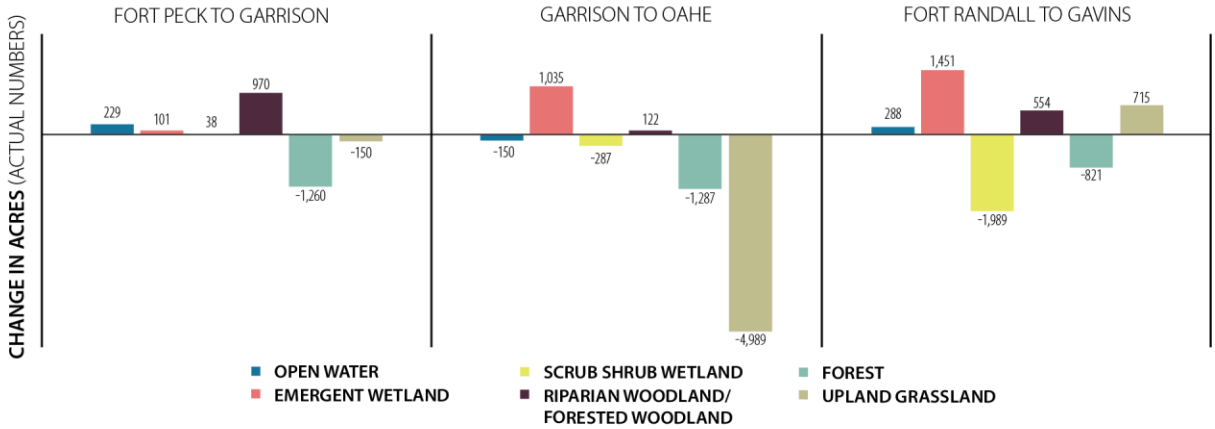


Figure 3-45. Modeled Changes in Acres of Fish and Wildlife Habitat Classes Compared to Alternative 1 – Upper River

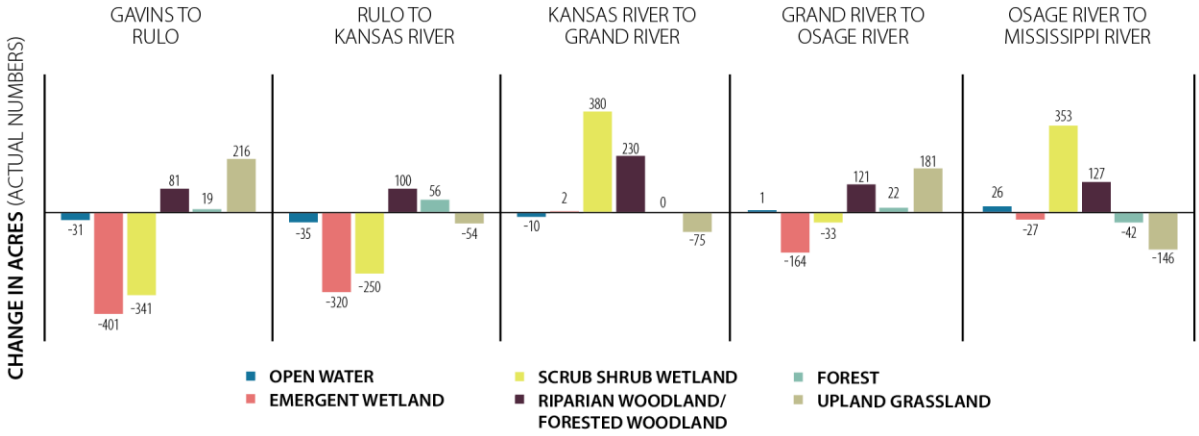


Figure 3-46. Modeled Change in Acres of Fish and Wildlife Habitat Classes Compared to Alternative 1 – Lower River

Fish and Wildlife Habitat Classes and Wetland Habitat Classes

Overall, under Alternative 5 the riparian woodland/forested wetland habitat class would have the greatest increasing trend compared to Alternative 1. Open water and emergent wetland would also have an increasing trend and scrub shrub wetland, forest, and upland grassland would have a decreasing trend as modeled. The modeling results presented for fish and wildlife habitat and wetland habitat classes in each study reach are for the POR (82 years).

Depth Classes

For all river reaches combined, the 3–6 and 6–9 foot depth classes would have an increasing trend in the overwintering late period. The 3–6, 6–9, and 12–18 foot depth classes would have an increasing trend in the early spawning period. The 3–6 foot depth class would have an increasing trend in the late spawning period. The 0–3 foot depth class would have an increasing trend in the summer rearing and growth period. The 0–3, 9–12, 12–18, and greater than 18 foot depth classes would have an increasing trend in the overwintering early period. These increases would benefit species that use the depth classes during a specific period. Adverse impacts could occur to species that require depth classes that decrease during a specific period (Figure 3-45 and Figure 3-46). A summary of the trend in depth classes within each of the eight study reaches follows. More information regarding the depth classes can be found in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

Upper River

Fort Peck to Garrison: The 12–18 foot depth class would have the greatest increasing trend (88.2 percent) during the overwintering early period and the 6–9 foot depth class would have the greatest decreasing trend (47.7 percent) in the overwintering early period.

Garrison to Oahe: The 6–9 foot depth class would have the greatest increasing trend (10.9 percent) during the overwintering late period and the 12–18 foot depth class would have the greatest decreasing trend (44.1 percent) in the late spawning period.

Fort Randall to Gavins Point: The 12–18 foot depth class would have the greatest increasing trend (13.2 percent) during the late spawning period and the 9–12 foot depth class would have the greatest decreasing trend (34.7 percent) in the late spawning period.

Lower River

Gavins Point to Rulo: The 6–9 foot depth class would have the greatest increasing trend (56.9 percent) during the late spawning period and the greater than 18 foot depth class would have the greatest decreasing trend (4.4 percent) in the early spawning period.

Rulo to Mississippi River: The 0–3 foot depth class would have the greatest increasing trend (13.6 percent) during the late spawning period and the 3–6 foot depth class would have the greatest decreasing trend (7.2 percent) in the summer rearing and growth period.

Flow Occurrences Below 9,000 cfs in the Fort Randall to Gavins Point Reach

The total number of flow occurrences and the average number per day below 9,000 cfs in the Fort Randall reach would have an increasing trend under Alternative 5 compared to Alternative

1 as modeled for the POR (82 years). Therefore, temporary adverse negligible impacts would be assumed to occur to fish and wildlife habitat and associated assemblages and taxa in the Fort Randall reach compared to Alternative 1.

Mechanical ESH Construction

Under Alternative 5, an average of 309 acres of ESH would be constructed annually in years where construction is needed. Compared to Alternative 1, 202 more acres of ESH would be constructed annually. The impacts from ESH construction under Alternative 5 would be the same intensity and duration as Alternative 1 but would also occur in the Fort Randall reach.

Fall Reservoir Release for ESH Creation

Habitat creating flows of sufficient magnitude and duration would increase the area of fish and wildlife habitat on the river by increasing deposition, assuming sediment is available. This would increase the abundance and diversity of fish and wildlife species that use this habitat. The implementation of a high fall ESH-creating reservoir release for the least tern and piping plover from Gavins Point, Fort Randall, and Garrison in combination with the other flow management actions and changes to channel geometry would cause an increase in the acres of all wetland habitat classes.

Spawning Habitat Construction

The impacts from spawning habitat construction under Alternative 5 would be the same as described for Alternative 3.

Channel Reconfiguration for Creation of Early Life Stage Pallid Habitat (IRC)

The impacts from channel reconfiguration for creation of early life stage pallid habitat (IRC) under Alternative 5 would be the same as described for Alternative 3.

Habitat Development and Land Management on MRRP Lands

The impacts from habitat development and land management under Alternative 5 would be the same as described for Alternative 3.

Conclusion

Overall, adverse impacts to fish and wildlife from impacts of management actions under Alternative 5 would be temporary and construction related. There would be an increasing trend towards wetter habitat classes such as forested wetland and riparian woodland as modeled under Alternative 5 compared to Alternative 1. Alternative 5 would not cause significant impacts to fish and wildlife given that adverse impacts would be temporary and negligible to small and long-term beneficial impacts would occur from habitat construction.

3.5.2.9 Alternative 6 – Pallid Sturgeon Spawning Cue

Environmental Quality

The results of the modeling of metrics for fish and wildlife habitat classes and wetland habitat classes under Alternative 6 are included in Figure 3-47 and Figure 3-48. The percent change in

the acres for each metric from the implementation of flow related management actions under Alternative 6, compared to Alternative 1, including spawning cue releases from Gavins Point are summarized in the following sections.

Fish and Wildlife Habitat Classes and Wetland Habitat Classes

Overall, under Alternative 6 the riparian woodland/forested wetland habitat class would have the greatest increasing trend compared to Alternative 1. Open water, emergent wetland, and scrub shrub wetland would also have an increasing trend and forest and upland grassland would have a decreasing trend as modeled. The modeling results presented for fish and wildlife habitat and wetland habitat classes in each study reach are for the POR (82 years).

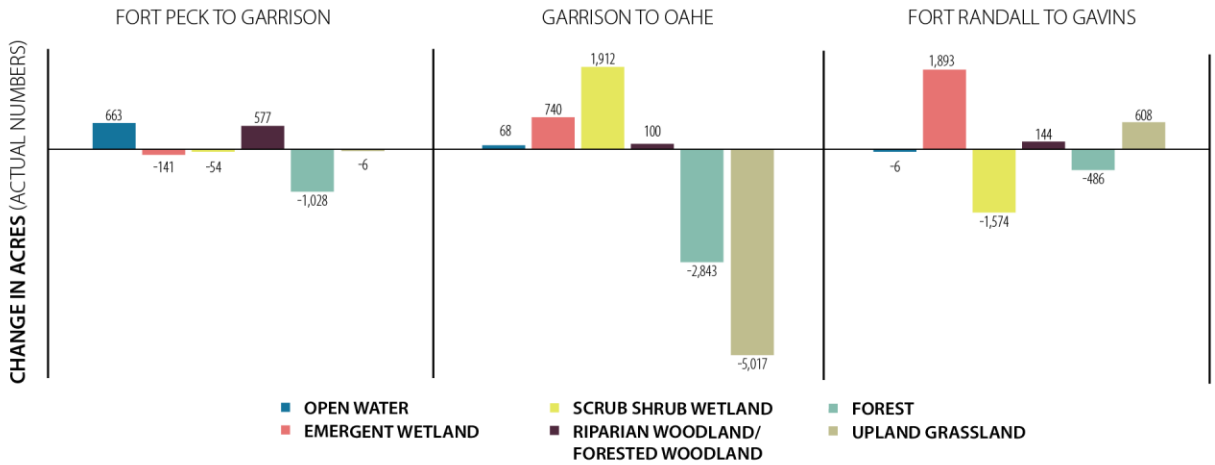


Figure 3-47. Modeled Change in Acres of Fish and Wildlife Habitat Classes Compared to Alternative 1 – Upper River

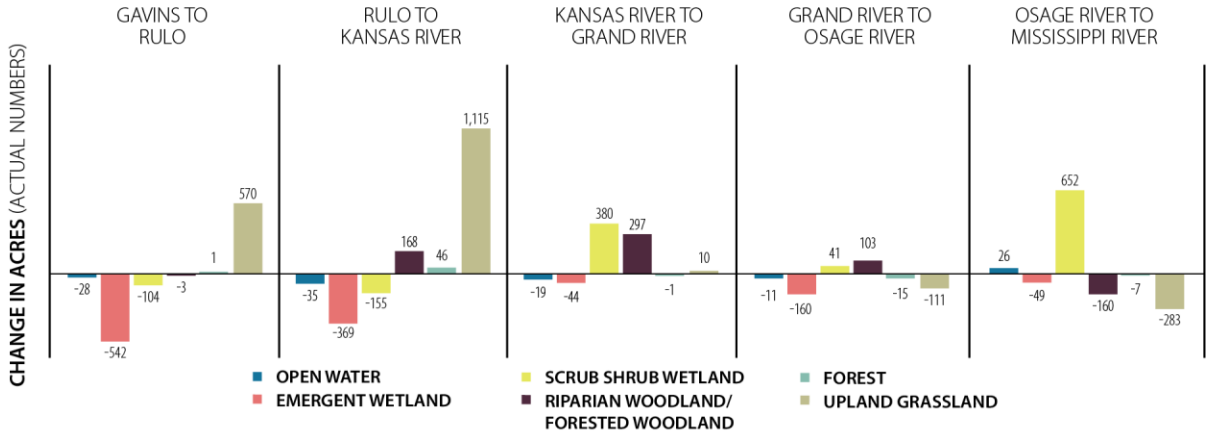


Figure 3-48. Modeled Change in Acres of Fish and Wildlife Habitat Classes Compared to Alternative 1 – Lower River

Depth Classes

For all river reaches combined, the 0–3, 6–9, 9–12, and 12–18 foot depth classes would have an increasing trend in the overwintering late period. The 0–3, 3–6, and greater than 18 foot depth classes would have an increasing trend in the early spawning period. The 0–3, 6–9, and greater than 18 foot depth classes would have an increasing trend in the late spawning period. The 3–6, 9–12, and 12–18 foot depth classes would have an increasing trend in the summer rearing and growth period. The 9–12 and 12–18 foot depth classes would have an increasing trend in the overwintering early period. These increases would benefit species that use the depth classes during a specific period. Adverse impacts could occur to species that require depth classes that decrease during a specific period (Figure 3-47 and Figure 3-48). A summary of the trend in depth classes within each of the eight study reaches follows. More information regarding the depth classes can be found in the "Fish and Wildlife Environmental Consequences Analysis Technical Report" available online (www.moriverrecovery.org).

Upper River

Fort Peck to Garrison: The 9–12 foot depth class would have the greatest increasing trend (42.1 percent) during the overwintering late period and the 9–12 foot depth class would have the greatest decreasing trend (13.1 percent) in the late spawning period.

Garrison to Oahe: The 6–9 foot depth class would have the greatest increasing trend (5.5 percent) during the overwintering late period and the 6–9 foot depth class would have the greatest decreasing trend (9.9 percent) in the late spawning period.

Fort Randall to Gavins Point: The 9–12 foot depth class would have the greatest increasing trend (21.9 percent) during the overwintering early period and the 9–12 foot depth class would have the greatest decreasing trend (35.0 percent) in the late spawning period.

Lower River

Gavins Point to Rulo: The 9–12 foot depth class would have the greatest increasing trend (7.5 percent) during the overwintering early period and the 0–3 and 3–6 foot depth classes would have the greatest decreasing trend (5.5 percent) in the summer rearing and growth period.

Rulo to Mississippi River: The 0–3 foot depth class would have the greatest increasing trend (9.4 percent) during the late spawning period and the 3–6 foot depth class would have the greatest decreasing trend (6.9 percent) in the summer rearing and growth period.

Flow Occurrences Below 9,000 cfs in the Fort Randall to Gavins Point Reach

The total number of flow occurrences and the average number per day below 9,000 cfs in the Fort Randall reach would have an increasing trend under Alternative 6 compared to Alternative 1 as modeled for the POR (82 years). Therefore, temporary adverse negligible impacts would be assumed to occur to fish and wildlife habitat and associated assemblages and taxa in the Fort Randall reach compared to Alternative 1.

Mechanical ESH Construction

Under Alternative 6, an average 303 acres of ESH would be constructed annually in years where construction is needed. Compared to Alternative 1, 196 more acres of ESH would be

constructed annually. The impacts from ESH construction under Alternative 6 would be the same in intensity and duration as Alternative 1 but would also occur in the Fort Randall reach.

Spawning Cue Releases

While the spawning cue releases under Alternative 1 and Alternative 6 are bimodal, the flow rates and conditions and characteristics of these flows differ and are based on slightly different system requirements. However, overall the temporary adverse impacts from implementation of the spawning cue releases under Alternative 6 would be small compared to existing conditions, similar to those described under Alternative 1. However, long-term beneficial impacts could occur on fish and wildlife if hydrology provided in channel margins, off-channel areas, and floodplain areas allows the creation of early successional plant communities including wetland habitat. Construction of fish and wildlife habitat would result in a long-term net increase in native vegetation and fish and wildlife habitat in localized areas.

Spawning Habitat Construction

The impacts from spawning habitat construction under Alternative 6 would be the same as described for Alternative 3.

Channel Reconfiguration for Creation of Early Life Stage Pallid Habitat (IRC)

The impacts from channel reconfiguration for creation of early life stage pallid habitat (IRC) under Alternative 6 would be the same as described for Alternative 3.

Habitat Development and Land Management on MRRP Lands

The impacts from habitat development and land management under Alternative 6 would be the same as described for Alternative 3.

Conclusion

Overall, adverse impacts to fish and wildlife from impacts of management actions under Alternative 6 would be temporary. There would be an increasing trend towards wetter habitat classes as modeled under Alternative 6 compared to Alternative 1. Alternative 6 would not cause significant impacts to fish and wildlife given that adverse impacts would be temporary and negligible to small and long-term beneficial impacts would occur from habitat construction.

3.5.2.10 Invasive Species

The introduction or establishment of invasive species could adversely impact fish and wildlife habitat classes and associated assemblages and taxa. These types of impacts could occur under any of the alternatives where there are construction activities or disturbed substrate but the level of impact would vary depending on the amount of disturbance at each construction site.

In areas where there is newly deposited or disturbed substrate following management actions, such as flow-related management actions, invasive plant species could colonize and spread into adjacent areas that provide habitat for fish and wildlife. The impacts from the spread of invasive plant species would be localized but long-term if invasive plants are left untreated. These

impacts would be small compared to the amount of fish and wildlife habitat available on the Missouri River and would result in a relative small change to the condition of the resource.

In accordance with Executive Order 13122, federal agencies may not authorize, fund, or carry out actions that are likely to cause or promote the introduction or spread of invasive species. Any management actions taken would be evaluated on a site specific level to ensure that compliance with Executive Order 13122 is met. It is not expected that any invasive aquatic wildlife species would spread because of any of the management actions. Therefore, there would be negligible adverse impacts from invasive wildlife species.

3.5.2.11 Commercial Fisheries

Changes in total commercial fish harvest can be influenced by numerous factors including changes in reporting requirements, river levels and water clarity, health advisories on fish consumption, removal of certain species from the commercial fish list in specific areas, and market demand (Tripp et al. 2012). The Management Plan alternatives are anticipated to have negligible impacts on the commercial fishery because it is not anticipated that the management actions would lead state agencies to revise existing commercial fishing regulations over the implementation timeframe. It is also not anticipated that the USFWS would revoke the Similarity of Appearance provision for shovelnose sturgeon in the foreseeable future.

3.5.2.12 Tribal Resources

Fish, wildlife, and plant species important to Tribes could be impacted temporarily in localized areas during construction if activities were performed in areas used by Tribes causing small adverse impacts. Long-term beneficial impacts could occur from an increase in fish and wildlife habitat construction that support species important to Tribes. Additional information on the importance of fish and wildlife to Tribes is included in the Section 3.20, Tribal Interests (Other).

3.5.2.13 Climate Change

Despite the many unknowns related to the effects of climate change, understanding how ecosystems and habitats will respond to climate change is important to evaluating the potential effects of the alternatives on fish and wildlife habitat.

An increase in the frequency of spring pulses or flooding that would inundate fish and wildlife habitat more frequently could cause changes in the acres of individual habitat classes with increases in wetter habitats (i.e., open water, emergent wetland, scrub shrub wetland, and riparian woodland/forested wetland) and decreases in drier habitats (i.e., forest and upland grassland) if precipitation and streamflow increase. These potential changes in acres of habitat classes would be minimized if the frequency of a completed pulse decreases due to exceeding flood targets more frequently if precipitation and streamflow increase. Maintenance of aquatic habitats could also occur more frequently sustaining important breeding and foraging habitat for fish and wildlife species. Decreases in the frequency of spring pulses, increased drought conditions, or decreased frequency of all pulses due to decreased System storage from increased sedimentation could have the opposite effect (i.e., increases in drier habitats and decreases in wetter habitats).

The depth class variability modeled within periods could change, with an increase in the deeper depth classes when there is an increase in the frequency of spring pulses or flooding or increases in the shallower depth classes when the frequency of spring pulses, increased

drought conditions, or decreased frequency of all pulses occur. The number of flow occurrences below 9,000 cfs in the Fort Randall reach could also fluctuate depending on whether there are increases or decreases in pulses and if flooding or drought conditions occur in this reach from impacts of climate change. A change in events, such as flow pulses or frequency of flooding and drought conditions, that does not correlate to the life history events (e.g., breeding, hatching, and flowering) of species on which they are dependent (e.g., pollination, prey) could mean a species does not have the necessary resources available during critical periods. The changes in events from management actions could increase similar impacts to fish and wildlife expected to occur from climate change. Climate change could also influence commercial and recreational fisheries in reservoirs if lower reservoir elevations occur due to setting the pulse magnitude too high during period of decreased peak snow water equivalent that was not accurately forecasted.

Increases in invasive species from disturbance during construction of ESH, channel reconfiguration for construction of early life stage pallid sturgeon habitat, and habitat development and land management on MRRP lands could add to the expected increase in invasive species from climate change. Therefore, it is assumed that the conclusions described for each alternative would not vary substantially under the expected climate change scenario.

3.5.2.14 Cumulative Impacts

Past and present actions that have adversely impacted fish and wildlife and their habitat include any actions which resulted in the loss, degradation, or fragmentation of habitat along the Missouri River mainstem and the floodplain. These actions include past construction, operation, and maintenance of the mainstem reservoir system, construction of levees, conversion of habitat to agriculture (e.g., crop production, animal pasturing/grazing), and other land uses (e.g., urban, residential, commercial, and industrial), and Missouri River bed degradation and aggradation. These actions have altered natural river flow, floodplain inundation, and sediment regimes, and adversely impacted habitat for many native fish and other aquatic species in the Missouri River. Any past or present actions which involve construction or use of heavy equipment for maintenance may have impacted fish and wildlife species temporarily due to noise and visual disturbances.

Water depletions from the Missouri River for agriculture, municipal, and industrial use may have adversely impacted fish and wildlife species that use wetland habitat by reducing groundwater elevations needed to maintain healthy wetland habitats along the Missouri River floodplain. Construction of the mainstem reservoir system has created barriers to fish passage and reduced downstream drift of embryos and invertebrates. Channelization and bank stabilization infrastructure replaces natural river banks and has cut off access by some species from the banks which are used for various stages of their life history (e.g., nesting of softshell turtles); fragmented suitable habitats; and created unnatural shorelines.

Some of the Missouri River reservoirs are stocked artificially with various species of fishes, some nonnative, to support sport fisheries (Bureau of Reclamation 2003; USACE 2003c; USACE 2007c; USACE 2008; USACE 2010a). Past fishery stocking and management has caused a reduction in the abundance of native fishes from competition and inadequate amounts of biological resources available to support both populations; reworking of the food web; and harboring and introducing pathogens.

Reasonably foreseeable future actions which may adversely impact fish and wildlife and their habitat include future transportation and utility corridor development, conversion of habitat for agriculture and other land uses, and water table depletion due to withdrawals from the Missouri

River. These ongoing actions may result in continued loss, degradation, or fragmentation of habitat within the Missouri River basin. Impacts of these reasonably foreseeable future actions would depend on the timing and location of specific actions. These actions are expected to result in a long-term small adverse impact to fish and wildlife and their habitat.

Past, present, and reasonably foreseeable future projects and actions that create, develop, and/or manage fish and wildlife life habitat have benefited or may benefit fish and wildlife species. These actions include the USACE Continuing Authority Programs, USFWS National Wildlife Refuge System Lands Management, USFWS Partners for Fish and Wildlife Program, NRCS Easement Programs, NRCS Technical and Financial Assistance Programs, EPA Section 319 Non-Point Source Grant Program, and Tribal programs and actions. These actions are expected to have long-term beneficial impacts to fish and wildlife and their habitat.

Cumulative impacts from other past, present, and reasonably foreseeable future actions would be the same for all alternatives. Alternative 1 would result in temporary adverse impacts, but long term negligible to small beneficial impacts to fish and wildlife. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts associated with Alternative 1 would be both beneficial and adverse. Adverse impacts would occur primarily due to actions that contribute to loss, degradation, or fragmentation of habitat, and disturbance or displacement of individuals. Beneficial impacts would occur as a result of land acquisition and habitat construction and management within the Missouri River basin. The implementation of Alternative 1 would provide a small contribution in context of cumulative impacts to fish and wildlife.

Alternative 2 would result in similar impacts to Alternative 1, but temporary large impacts could occur during ESH construction in the upper river due to a substantial increase in ESH construction compared to Alternative 1. The implementation of Alternative 2 would contribute temporary, small, mainly beneficial impacts to fish and wildlife from the implementation of low summer flows and floodplain connectivity and long-term, small to large beneficial impacts from an increase in ESH construction, construction of early life stage pallid habitat, and habitat development and land management on MRRP lands. When combined with other past, present, and reasonably foreseeable future actions, Alternative 2 would result in adverse and beneficial cumulative impacts largely based on changes in habitat availability and quality, temporary habitat disturbances, land acquisition, and habitat construction and management. The implementation of Alternative 2 would provide a small beneficial contribution in context of cumulative impacts to fish and wildlife.

Implementation of Alternative 3 would result in adverse and beneficial impacts, but would contribute long-term small beneficial impacts from an increase in ESH construction to cumulative impacts. When combined with other past, present, and reasonably foreseeable future actions, Alternative 3 would result in adverse and beneficial cumulative impacts largely based on changes in habitat availability and quality, temporary habitat disturbances, land acquisition, and habitat construction and management. The implementation of Alternative 3 would provide a negligible beneficial contribution in context of cumulative impacts to fish and wildlife.

Alternative 4 would result in adverse and beneficial impacts, but temporary adverse impacts from the spring reservoir release and long-term small beneficial impacts from an increase in ESH construction and an additional increase in habitat from the spring reservoir release. When combined with other past, present, and reasonably foreseeable future actions, Alternative 4 would result in adverse and beneficial cumulative impacts largely based on changes in habitat

availability and quality, temporary habitat disturbances, land acquisition, and habitat construction and management. The implementation of Alternative 4 would provide a negligible beneficial contribution in context of cumulative impacts to fish and wildlife.

Alternative 5 would contribute adverse and beneficial impacts, but temporary adverse impacts could result from the fall reservoir release, and long-term small beneficial impacts would result from an increase in ESH construction and an additional increase in habitat from the fall reservoir release. When combined with other past, present, and reasonably foreseeable future actions, Alternative 5 would result in adverse and beneficial cumulative impacts largely based on changes in habitat availability and quality, temporary habitat disturbances, land acquisition, and habitat construction and management. The implementation of Alternative 5 would provide a negligible beneficial contribution in context of cumulative impacts to fish and wildlife.

Alternative 6 would contribute similar adverse and beneficial impacts but long-term small beneficial impacts would result from an increase in ESH construction compared to Alternative 1. When combined with other past, present, and reasonably foreseeable future actions, Alternative 6 would result in adverse and beneficial cumulative impacts largely based on changes in habitat availability and quality, temporary habitat disturbances, land acquisition, and habitat construction and management. The implementation of Alternative 6 would provide a negligible beneficial contribution in context of cumulative impacts to fish and wildlife.

3.6 Other Special-Status Species

3.6.1 Affected Environment

In addition to the three primary species listed on the USFWS endangered species list (i.e., pallid sturgeon, least tern, and piping plover) that are evaluated in this EIS, other special-status species that may be present within the geographic scope of the MRRMP-EIS have been identified. These species include other ESA-listed species and other special-status species.

A total of 125 additional species that may occur in the area have been given a special-status designation at the federal or state level. These species include 18 plants, 31 birds, 11 mammals, 18 reptiles and amphibians, 23 fish, 20 mussels, and 4 insects (Appendix E: Other Special-Status Species). Twelve of the special-status species in Appendix E are ESA-listed. The bald eagle and golden eagle are not listed under the ESA but are protected at the federal level under the Bald and Golden Eagle Protection Act (BGEPA). Many of the migratory bird species are protected at the federal level under the Migratory Bird Treaty Act (MBTA). All other species in Appendix E are listed in one or more of the states within the area.

The MRRMP-EIS considers and assesses the potential impacts to all special-status species that may occur within the geographic scope of the MRRMP-EIS. Species were evaluated to determine if they would be analyzed in detail. A general analysis of those species not analyzed in detail is provided in Appendix E. In this appendix, the potential impacts to each special-status species are listed.

The remainder of the analysis focuses on five species that were identified based on the potential for impacts that could occur to individuals, populations, or their habitat in areas where management actions could occur. A general analysis of fish and wildlife habitat used by special-status species is expanded in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org). For the purposes of resources described and analyzed in this section, the term “upper river basin” refers to the reaches upstream of Gavins Point Dam and the term “lower river basin” refers to reaches located downstream of Gavins Point Dam.

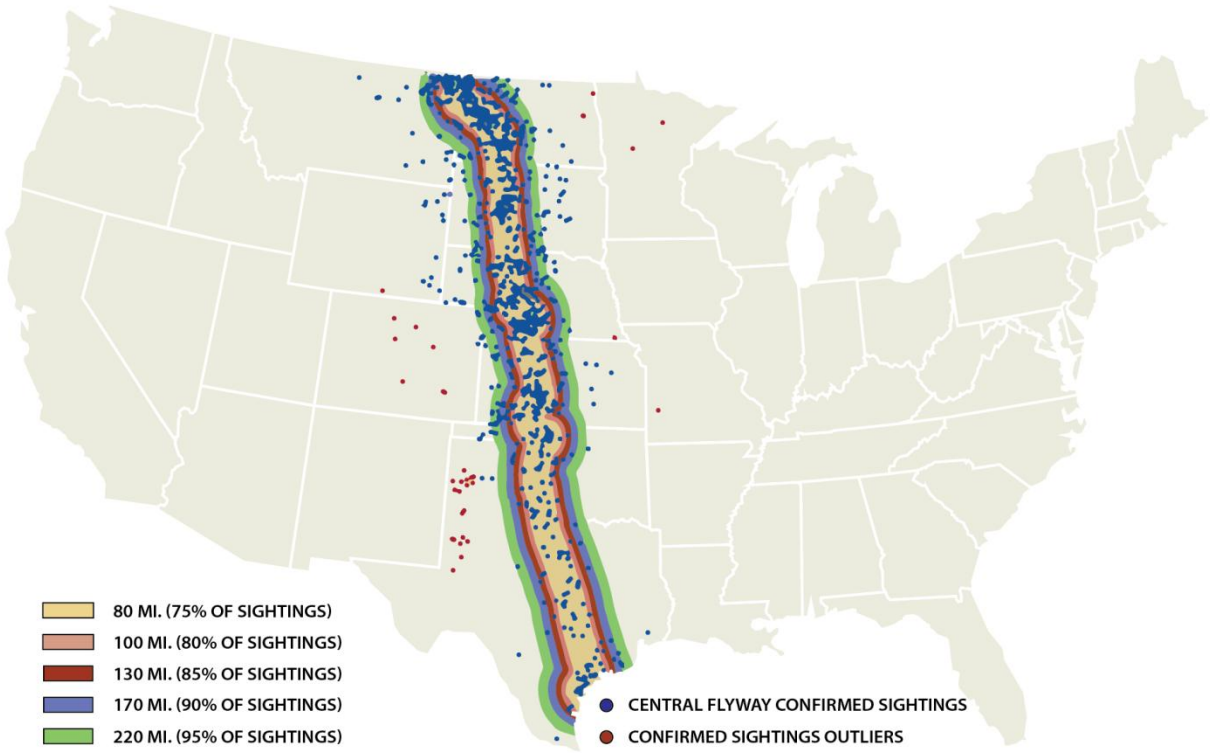
3.6.1.1 Federally Listed Species

Federally listed species considered in this MRRMP-EIS are those designated as endangered or threatened under ESA or under the BGEPA and found within the geographic scope of the MRRMP-EIS.

Whooping Crane

The whooping crane (*Grus americana*) is currently listed as endangered under ESA. This species was listed as threatened with extinction in 1967 and endangered in 1970 (CWS and USFWS 2007). Its status was grandfathered into the ESA in 1973 (CWS and USFWS 2007). The whooping crane is North America’s tallest bird, standing at 5 feet. The Aransas-Wood Buffalo Population—named for the bird’s wintering grounds at Aransas National Wildlife Refuge on the Gulf Coast of Texas and Wood Buffalo National Park of Canada in northern Alberta—is the only existing natural population consisting of an estimated 279 individuals as of April 2011. Other populations are listed as experimental and non-essential populations (USFWS 2012).

Whooping cranes of the Aransas-Wood Buffalo Population leave their nesting grounds in Canada each fall in September and October and arrive on their Texas wintering grounds in October and November. They return to their nesting grounds in the spring, leaving the Texas coast in March and April and arriving in Alberta and Northwest Territories in April and May (CWS and USFWS 2007). During spring and fall migrations whooping cranes traverse central North America via the Central Flyway, which overlaps a portion of the upper Missouri River Basin (Figure 3-49). Whooping cranes of the Aransas-Wood Buffalo Population are rarely sighted outside the Central Flyway (USFWS 2007). Thus, whooping cranes are only likely to be present along the Missouri River north of Gavins Point Dam, from September-November and March-May.



Source: USFWS 2007

Figure 3-49. Whooping Crane Sighting Corridor

The USFWS maintains a list of the U.S. counties in which the population is known or is believed to occur. This list includes all counties containing a portion of the Missouri River and its meander belt from the headwaters of Fort Peck Lake in Montana downstream to Yankton County, South Dakota. None of these counties contain critical habitat for the whooping crane.

Migrating whooping cranes use a variety of wetlands and other habitats along the northern portion of the Missouri River (including inland marshes, lakes, ponds, wet meadows, rivers, and agricultural fields) as stopover habitat for foraging, feeding, and roosting. However, wetland mosaics, consisting of shallow, seasonally, and semi-permanently flooded palustrine wetlands, appear to be the most suitable habitat. Whooping cranes frequently use portions of the Platte River, west of the Missouri River, as stopover habitat during spring and fall migrations. Critical habitat has been designated along the Platte River in Nebraska (43 FR 20938).

Loss and degradation of migratory habitat, primarily due to conversion of wetland habitat for agricultural use, is one of the main threats to this species (Urbanek and Lewis 2015). Transportation and energy infrastructure development has also contributed to a loss of whooping crane habitat in the Central Flyway and droughts are an ongoing threat (USFWS 2012).

Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) was delisted from the Endangered Species List in August of 2007 (72 FR 37346), but has remained protected under the BGEPA and the MBTA. The protection provided by the BGEPA is similar to the protection provided by the ESA in that no person or organization without a permit from the Secretary of the Interior can “take” a bald eagle, where “take” is defined by pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest, or disturb. The BGEPA also protects active and previously active bald eagle nesting sites (16 USC 668-668d).

The riparian habitat of the Missouri River and its associated reservoirs provides ample foraging, loafing, migration, and nesting habitat for the bald eagle throughout the geographic scope of this MRRMP-EIS. The bald eagle is a predatory raptor species that feeds on fish, birds, snakes, and small mammals. Bald eagles are common along the river and sightings are frequently reported. Bald eagles prefer mature trees, such as cottonwoods, to nest and roost. Flood-control operations, river-system maintenance, and bank-stabilization programs along the Missouri River have resulted in irregular flooding. The lack of spring flooding across the floodplain has resulted in a decrease in cottonwood regeneration north of the Platte River. As a result, cottonwood forests along this portion of the Missouri River are being replaced by species such as elm and ash trees, which are not suitable bald eagle nesting or roosting sites (MRRP 2008). Threats to bald eagles throughout their range include poaching, use of harmful pesticides, and collisions with vehicles and power lines (Buehler 2000).

Northern Long-Eared Bat

The northern long-eared bat (*Myotis septentrionalis*) was listed as a threatened species under ESA in 2015 (80 FR 17974). This small bat species occurs across much of the eastern and north central United States, encompassing 37 states and all Canadian provinces from the Atlantic coast west to the southern Northwest Territories and eastern British Columbia. During the summer months, the northern long-eared bat roosts underneath bark or in cavities of a variety of tree species, both live and dead, and may roost individually or in colonies. Summer roosting sites may also include caves, mines, or human-made structures, such as barns, other buildings, utility poles, window shutters, and bat houses (80 FR 17974). During the winter, the northern long-eared bat inhabits large caves or mines known as hibernacula (Caceres and Pybus 1997). Foraging habitat consists of forested areas or forested edges along rivers and lakes. Northern long-eared bats feed at dusk preying on moths, leafhoppers, caddisflies, and beetles while in flight or by gleaning insects from vegetation (USFWS 2015).

The northern long-eared bat was placed on the Endangered Species List due to severe impacts of white-nose syndrome, a fungal disease that has caused massive population declines in some portions of this species range (81 FR 1901). Other threats include habitat fragmentation, destruction, and modification from logging, oil/gas/mineral development, and wind energy development. Disturbances of hibernacula caused by recreational caving activities have also been documented as a potential threat to the northern long-eared bat (78 FR 61046). In January 2016 the USFWS published a Final 4(d) Rule which provides an exemption from incidental take

restrictions for northern long-eared bats occurring in areas not yet affected by white-nose syndrome (81 FR 1901).

Much of the upper and lower Missouri River runs through the range of the northern long-eared bat. The portion of the Missouri River in southeastern South Dakota, along the Iowa/Nebraska border, and through the entire state of Missouri is within the white-nose syndrome zone per the Final 4(d) Rule. Thus individuals in these areas are subject to full protection under ESA. Some of the counties adjacent to the Missouri River in Nebraska and Missouri have known hibernacula infected with white-nose syndrome. Efforts to identify and record hibernacula and maternity roost trees for the northern long-eared bat are ongoing (USFWS 2015).

Indiana Bat

The Indiana bat (*Myotis sodalis*) is listed as an endangered species under the ESA. This species was listed as in danger of extinction in 1967 and was grandfathered in under the ESA in 1973 (USFWS 2007). The range of the Indiana bat spans most of the eastern half of the United States, but the population is largely concentrated in southern Indiana. The Indiana bat is similar in size to the northern-long eared bat and has many of the same habitat requirements. However, the Indiana bat requires hibernacula with cooler temperatures than those used by the northern long-eared bat. The Indiana bat is more selective with roosting sites, showing preference for trees that are dying or dead, and has been found to select trees by size, species, and surrounding canopy cover (USFWS 2007). Like the northern long-eared bat, foraging habitat for the Indiana bat consists of forested areas or forested edges along rivers and lakes. Indiana bats feed while in flight on a variety of flying insects along rivers, lakes, and uplands. This species consumes up to half of its body weight in insects daily (USFWS 2016).

Within the geographic scope of the MRRMP-EIS, only the portion of the lower river in Missouri is within the range of the Indiana bat. Hibernating population estimates for the Indiana bat in Missouri show a downward trend from an estimated 399,000 in 1965 to 65,104 in 2005. As of 2006, 20 Indiana bat maternity colonies had been recorded in Missouri, some of which are in Chariton and Gasconade County, which are adjacent to the Missouri River. Two caves out of the six hibernacula designated as critical habitat for the Indiana bat in Missouri are in Franklin County, which is also adjacent to the Missouri River (USFWS 2007). Threats to this species include loss or alteration of cave and forest habitats and human disturbance of hibernating individuals (USFWS 2007).

Western Prairie Fringed Orchid

The western prairie fringed orchid (*Platanthera praeclara*) is listed as threatened under the ESA. This species was originally listed under ESA in 1989 due to habitat loss from conversion of prairie to cropland (54 FR 39857). This species is a perennial orchid found most often on unplowed, calcareous prairies and sedge meadows. The persistence of the western prairie fringed orchid is dependent on periodic disturbance by fire, mowing, or grazing, but these practices may also cause adverse effects and must be carefully implemented. Remaining threats to this species include the conversion of existing habitat to cropland and actions that directly or indirectly lower water levels in the rooting zone (USFWS 2009).

Within the geographic scope described for this project, the western prairie fringed orchid has extant populations in Sarpy and Otoe Counties, Nebraska; Pottawattamie and Mills Counties, Iowa; Atchison and Holt Counties, Missouri; and Leavenworth County, Kansas (USFWS 2009).

The USFWS also notes that this species is believed to occur in additional counties along the Missouri River in South Dakota, Nebraska, Iowa, Kansas, and Missouri.

3.6.1.2 State-Listed Species

The special-status species lists for seven states (Montana, North Dakota, South Dakota, Nebraska, Iowa, Kansas, and Missouri) were examined to determine the state-listed species that are known to occur or may occur within the geographic scope of the MRRMP-EIS. County-level data were used where available. The criteria for identifying species and how these species are organized vary from state to state. These species are listed in Appendix E along with a description of how each state within the geographic scope identifies their respective special-status species.

3.6.2 Environmental Consequences

The following analysis focuses on the whooping crane, bald eagle, northern long-eared bat, Indiana bat, and western prairie fringed orchid, identified by the USACE in consultation with USFWS. These species were identified because of their close association with habitats in the Missouri River and the Missouri River floodplain. This section describes the anticipated impacts to each of these species as a result of the actions under each of the alternatives. Impacts to other special-status species not identified for detailed analysis are described in general terms for each alternative.

3.6.2.1 Impacts Assessment Methodology

Impacts were analyzed based on changes to the amount of habitat associated with the species included in the Affected Environment section. The associated habitat was based on the fish and wildlife habitat classes modeled in all study reaches for the POR. Modeled results are summarized in Section 3.5, Fish and Wildlife Habitat and described in detail in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org). Thus, habitat impacts were used as a proxy for impacts to other special-status species. 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 (refer to the “H&H Technical Reports” available online at www.moriverrecovery.org).

Appendix E indicates which of the six habitat types is associated with each special-status species. Appendix E also indicates in which reach each species is known to occur or likely to occur. The geographic scope of this analysis includes the Missouri River and portions of its floodplain from Fort Peck Dam to the confluence with the Mississippi River. The area of analysis for impacts to special-status species is limited to those areas in which potential impacts of flow actions on fish and wildlife habitats were modeled, as described in Section 3.5, Fish and Wildlife Habitat. It is assumed that impacts to special-status species would be commensurate with impacts to habitats for which each species is associated, within the river reaches in which they are known to occur or may occur. With regard to the northern-long eared bat, it should be noted that impacts are discussed separately for the upper and lower river because the upper river (Fort Peck Lake to Gavins Point Dam) is outside the White-Nose Syndrome Zone. Therefore, only individuals occurring along the lower river (Gavins Point Dam to the mouth of the river) are subject to incidental take restrictions under ESA, in accordance with the 4(d) Rule (81 FR 1901).

Avoidance, minimization, and mitigation measures would be developed and occur at the site specific level when individual projects are implemented.

The No Action Alternative is considered the baseline against which the other alternatives are measured. Under the No Action Alternative, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, the No Action Alternative does 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.

3.6.2.2 Summary of Environmental Consequences

Table 3-15 summarizes the environmental impacts to the five species carried forward for detailed analysis by alternative. 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.

3.6.2.3 Impacts from Management Actions Common to All Alternatives

Vegetation Management, Predator Management, and Human Restriction Measures

Vegetation management on sandbars using mechanical and chemical methods would be implemented to maximize the availability of suitable nesting habitat for least tern and piping plover, as described in Chapter 2.0. The presence of work crews during initial vegetation management and annual maintenance activities could temporarily displace some special-status species, resulting in direct adverse impacts. Bald eagles roost and nest along riparian corridors and could use ESH for foraging and, therefore, could be temporarily displaced during vegetation management activities. Displacement of prey species such as small birds, mammals, and reptiles could indirectly, adversely impact bald eagles or other special-status species which use ESH for foraging, nesting, or loafing. Direct and indirect, adverse impacts to bald eagles would be negligible because displaced individuals would likely use adjacent habitats temporarily and return once maintenance crews leave the area. Potential impacts would be limited to the bird management areas in the upper Missouri River Basin, as described in Section 3.4, Piping Plover and Least Tern. Vegetation management is not anticipated to impact whooping cranes, northern long-eared bats, or western prairie fringed orchids because these species are not associated with sandbar habitat.

Predator management actions, as described in Chapter 2.0, could temporarily displace bald eagles or other special-status species which use ESH for foraging, nesting, or loafing. Temporary displacement of individuals due to the presence of humans would result in a direct, negligible, and adverse impact. Predator management actions are not anticipated to impact whooping cranes, northern long-eared bats, or western prairie fringed orchids because these species are not associated with sandbar habitat.

Table 3-15. Summary of Impacts to Other Special-Status Species

Species	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Whooping Crane	Direct and indirect, temporary, negligible adverse impacts from mechanical ESH construction. Long-term benefit from habitat development and land management on MRRP lands.	Same as Alternative 1 with an increasing trend (4%) in emergent wetland habitat within the upper river basin.*	Same as Alternative 1 with an increasing trend (1%) in emergent wetland habitat within the upper river basin.*	Same as Alternative 1 with a decreasing trend (−6%) in emergent wetland habitat within the upper river basin.*	Same as Alternative 1 with an increasing trend (4%) in emergent wetland habitat within the upper river basin.*	Same as Alternative 1 with an increasing trend (3%) in emergent wetland habitat within the upper river basin.*
Bald Eagle	Direct and indirect, temporary, negligible adverse impacts from mechanical ESH and early life stage pallid sturgeon habitat construction. Long-term benefit from 7,046 acres of land acquisition and habitat development and land management on MRRP lands.	Direct and indirect, temporary, negligible adverse impacts from mechanical ESH and early life stage pallid sturgeon habitat construction. Long-term benefit from 45,716 acres of land acquisition and habitat development and land management on MRRP lands. Increasing trend (9%) in woodland/forested wetland habitat. *	Direct and indirect, temporary, negligible adverse impacts from mechanical ESH and early life stage pallid sturgeon habitat construction. Long-term benefit from 1,772 acres of land acquisition and habitat development and land management on MRRP lands. Increasing trend (9%) in woodland/forested wetland habitat. *	Same as Alternative 3.	Same as Alternative 3.	Same as Alternative 3.

Species	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Northern Long-Eared Bat	Direct and indirect, temporary, negligible adverse impacts from mechanical ESH and early life stage pallid sturgeon habitat construction. Long-term benefit from 7,046 acres of land acquisition and habitat development and land management on MRRP lands.	Direct and indirect, temporary, negligible adverse impacts from mechanical ESH and early life stage pallid sturgeon habitat construction. Long-term benefit from 45,716 acres of land acquisition and habitat development and land management on MRRP lands. Decreasing trend (−1%) in woodland/forested wetland and forest habitats in the upper basin and increasing trend (21%) in the lower basin.*	Direct and indirect, temporary, negligible adverse impacts from mechanical ESH and early life stage pallid sturgeon habitat construction. Long-term benefit from 1,772 acres of land acquisition and habitat development and land management on MRRP lands. Decreasing trend (−4%) in woodland/forested wetland and forest habitats in the upper basin and increasing trend (10%) in the lower basin.*	Same as Alternative 3 with no change (0%) in woodland/forested wetland and forest habitats in the upper basin and increasing trend (14%) in the lower basin.*	Same as Alternative 3 with a decreasing trend (−4%) in woodland/forested wetland and forest habitats in the upper basin and increasing trend (9%) in the lower basin.*	Same as Alternative 3 with a decreasing trend (−9%) in woodland/forested wetland and forest habitats in the upper basin and increasing trend (6%) in the lower basin.*
Indiana Bat	Direct and indirect, temporary, negligible adverse impacts from early life stage pallid sturgeon habitat construction. Long-term benefit from 7,046 acres of land acquisition and habitat development and land management on MRRP lands.	Direct and indirect, temporary, negligible adverse impacts from early life stage pallid sturgeon habitat construction. Long-term benefit from 45,716 acres of land acquisition and habitat development and land management on MRRP lands. Increasing trend (21%) in woodland/forested wetland and forest habitats in the lower river basin.*	Direct and indirect, temporary, negligible adverse impacts from early life stage pallid sturgeon habitat construction. Long-term benefit from 1,772 acres of land acquisition and habitat development and land management on MRRP lands. Increasing trend (10%) in woodland/forested wetland and forest habitats in the lower river basin.*	Same as Alternative 3 with an increasing trend (14%) in woodland/forested wetland and forest habitats in the lower river basin.*	Same as Alternative 3 with an increasing trend (9%) in woodland/forested wetland and forest habitats in the lower river basin.*	Same as Alternative 3 with an increasing trend (6%) in woodland/forested wetland and forest habitats in the lower river basin.*

Species	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Western Prairie Fringed Orchid	Any lands acquired for habitat development and land management that are suitable habitat for western prairie fringed orchid would be protected and would benefit the species. These beneficial impacts would be negligible as most lands acquired would most likely be previously plowed/disturbed/accredited lands that are likely not suitable habitat for western prairie fringed orchid.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.

*In a typical year, based on EQ account modeling results, which are described in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

Human restriction measures designed to avoid interactions between humans and least terns and piping plovers would entail the installation of temporary barricades and signage, as described in Chapter 2.0. Like vegetation and predator management activities, the presence of humans during installation could temporarily displace bald eagles or other special-status species which use ESH for foraging, nesting, or loafing resulting in direct or indirect, negligible, and adverse impacts. However, restrictions designed to reduce the frequency of human interactions with special-status species could benefit species that use ESH over the long term, including bald eagles. Human restrictions would not impact whooping cranes, northern long-eared bats, or western prairie fringed orchids because these species are not associated with sandbar habitat.

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

Management actions to be implemented under Alternative 1 that could potentially, adversely impact other special-status species include mechanical construction and maintenance of ESH and early life stage pallid sturgeon habitat. Mechanical construction of ESH would involve excavation and placement of sand using typical large construction equipment if river conditions are low or excavation and placement by hydraulic dredge if river conditions are higher. Under Alternative 1, mechanical ESH construction would occur on average at a rate of 107 acres per year. ESH construction would only occur in the upper river basin in the Garrison and Gavins Point reaches under Alternative 1.

Early life stage pallid sturgeon habitat construction would consist of physical manipulation of the riverbed, bank, and/or channel structures to create or improve areas for pallid sturgeon habitat. These actions would be limited to the lower river basin. A total of 3,999 additional acres of early life stage pallid sturgeon habitat would be constructed under Alternative 1. Land acquisition requirements for pallid sturgeon habitat construction would result in the estimated land acquisition of 7,046 acres of land in the lower river basin (1,848 acres from Ponca to Sioux City; 5,198 acres from Rulo to Kansas River). The USACE must typically purchase enough land from willing sellers to accommodate the pallid sturgeon habitat project and provide a buffer between the project and adjacent lands. This additional land would be used for additional habitat development.

Impacts to special-status species under Alternative 1 would also include habitat development and land management on MRRP lands as well as those described in Section 3.6.2.3, Impacts from Management Actions Common to All Alternatives. Potential impacts of Alternative 1 on each species are described below. Modeled acres of habitat, under typical hydrological conditions for the POR, which could support special-status species are summarized by habitat type and reach in the environmental consequences discussion of “Fish and Wildlife Habitat” and described in detail in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

Whooping Crane

Under Alternative 1, potential temporary, direct, adverse impacts to whooping cranes could occur due to noise and visual disturbances during ESH construction and maintenance activities. These activities could result in temporary displacement of individuals for the duration of construction and maintenance activities. Potential impacts would be limited to the Garrison Reach, where whooping cranes are known to use wetlands adjacent to the Missouri River as stopover habitat; this would only potentially occur during fall migration because seasonal

restrictions on ESH construction activities would coincide with the spring whooping crane migration.

Channel reconfiguration for creation of early life stage pallid sturgeon habitat under Alternative 1 would have no impact on whooping cranes because these actions would be limited to the reaches from Ponca, Nebraska to the mouth of the river, near St. Louis. These reaches are outside the typical range of whooping cranes. Similarly, land acquisition required for creation of early life stage pallid sturgeon habitat would be located in the lower river basin, outside the typical range of whooping cranes, and would have no impact on whooping cranes.

Migratory whooping cranes are closely associated with emergent wetland habitat, which is not expected to be impacted by any of the management actions proposed under Alternative 1. No emergent wetland habitat would be lost under Alternative 1.

Overall, impacts to whooping cranes would be negligible because displaced individuals would likely use adjacent habitats temporarily and return to the area once maintenance crews and equipment are removed. Therefore, adverse impacts are not expected to be significant. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts to whooping cranes if habitats are improved or additional habitats are created.

Bald Eagle

Impacts to bald eagles under Alternative 1 would be both adverse and beneficial. Direct adverse impacts to bald eagles would include temporary displacement of individuals due to ESH and early life stage pallid sturgeon habitat construction activities. Temporary displacement of prey species could indirectly impact bald eagles. Impacts associated with ESH construction and maintenance activities would be limited to the upper river basin, while impacts from early life stage pallid sturgeon habitat construction would be limited to the lower river.

Under Alternative 1, woodland/forested wetland habitat comprises approximately 5 percent of total habitat in all modeled river reaches under the typical hydrological condition for the POR (for additional details on the EQ account modeling, see the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online at www.moriverrecovery.org). All riparian woodland/forested wetland habitat along the Missouri River represents potential bald eagle roosting and nesting habitat. Bald eagles could also be impacted by any action that results in the disturbance or removal of mature trees, which could serve as roosting or nesting sites, along the riparian corridor.

Direct and indirect, adverse impacts are anticipated to be temporary and negligible because displaced individuals would likely return upon completion of construction and maintenance activities or relocate to adjacent habitats. Therefore, adverse impacts are not expected to be significant. Acquisition and management of land in the lower river basin would result in direct, beneficial, long-term impacts to bald eagles. These impacts would be small due to the small amount of new lands to be acquired and managed for habitat conservation, compared to the amount of existing lands. Human restriction measures on ESH could also contribute to long-term benefits to bald eagles in the upper river basin, as described previously. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts if habitats are improved or additional habitats are created. Specific impacts would depend on the locations of management actions.

Northern Long-Eared Bat

Under Alternative 1, direct adverse impacts to the northern long-eared bat could occur as a result of ESH and early life stage pallid sturgeon habitat construction activities, if these actions resulted in the disturbance or removal of mature trees, which could serve as existing or potential roosting sites. The likelihood for the removal of mature trees would be low. Impacts associated with mechanical ESH construction would be limited to the upper river basin, while impacts from early life stage pallid sturgeon habitat construction would be limited to the lower river basin. Potential impacts would be temporary and would only occur during active construction periods. Tree removal is typically scheduled to occur outside of the primary migratory bird nesting season.

The spawning cue release only applies to the lower river, south of Gavins Point Dam, so there would be no impacts to northern long-eared bats in the upper river basin. Under Alternative 1, woodland/forested wetland and forest habitat comprises approximately 13 percent of total habitat in all modeled river reaches under the typical hydrologic conditions for the POR (for additional details on the EQ account modeling, see the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online at www.moriverrecovery.org). It is not anticipated that this flow action will alter or impact these habitats, therefore, continued implementation of the spawning cue releases would have no impacts to northern long-eared bats.

When these actions are considered within the larger context of the river and the amount of available habitat for the northern long-eared bat, impacts are anticipated to be temporary and negligible. Therefore, adverse impacts are not expected to be significant. Acquisition and management of land in the lower river basin and habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts if habitats are improved or additional habitats are created. Specific impacts would depend on the locations of management actions.

Indiana Bat

Alternative 1 would have both adverse and beneficial impacts to the Indiana bat. Only the portion of the lower river in the state of Missouri is within the range of the Indiana bat, thus only impacts downstream of Gavins Point Dam in the state of Missouri are considered and discussed in this impacts analysis for all of the alternatives.

ESH construction would not occur within the range of the Indiana bat and therefore, would have no impacts to this species. Early life stage pallid sturgeon habitat construction could result in direct or indirect, adverse impacts to Indiana bats if this action resulted in the disturbance or removal of mature trees, which could serve as existing or potential roosting sites. Potential impacts would be temporary and would only occur during active construction periods. Tree removal is typically scheduled outside of the primary migratory bird nesting season (April 1 – October 31).

Under Alternative 1, woodland/forested wetland and forest habitat comprises approximately 5 percent of total habitat in all modeled reaches under the typical hydrologic conditions for the POR (for additional details on the EQ account modeling, see the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online at www.moriverrecovery.org). Continued implementation of the spawning cue releases would have no impacts to Indiana bats or alter or impact the species habitat.

Direct and indirect impacts are anticipated to be adverse, temporary, and negligible considered within the larger context of the river and the amount of available habitat for the Indiana Bat. Therefore, adverse impacts are not expected to be significant. Acquisition and management of land in the lower river basin would result in direct, beneficial, long-term impacts to Indiana bats. These impacts would be small due to the small amount of new lands to be acquired and managed for habitat conservation, compared to the amount of existing lands. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts if habitats are improved or additional habitats are created. Specific impacts would depend on the locations of management actions.

Western Prairie Fringed Orchid

Alternative 1 would only result in adverse impacts to the western prairie fringed orchid if plants are crushed by construction equipment traversing the area to access construction or maintenance sites. The majority of unplowed prairie habitat remaining along the Missouri River is relatively small. Specific impacts would depend on the locations of management actions. Any lands acquired for habitat development and land management that are suitable habitat for western prairie fringed orchid would be protected and would benefit the species. These beneficial impacts would be negligible as most lands acquired would most likely be previously plowed/disturbed/accredited lands that are likely not suitable habitat for western prairie fringed orchid.

Other Special-Status Species

Under Alternative 1, direct and indirect adverse impacts to other special-status species would be similar to those described in Section 3.5, Fish and Wildlife Habitat and would be commensurate with impacts to habitat. ESH construction and channel reconfiguration for creation of early life stage pallid sturgeon habitat could have both beneficial and adverse impacts, depending on the timing and location of specific management actions. Special-status species could benefit in the long term, although some species would be temporarily displaced during construction activities resulting in direct or indirect, temporary, adverse impacts. Impacts would be greatest on aquatic special-status species, and could include temporary increases in turbidity, sedimentation, or alteration of benthic habitat. Species which are not associated with these habitats will not be impacted under Alternative 1. Adverse impacts are anticipated to be negligible because displaced individuals would likely return upon completion of construction and maintenance activities or relocate to adjacent habitats. Land acquisition and habitat development and land management on MRRP lands would have direct and indirect, long-term, small, beneficial impacts on other special-status species because lands adjacent to the Missouri River would be acquired and managed for conservation. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts if habitats are improved or additional habitats are created. The type, duration, and intensity of all impacts, as well as specific species which could be impacted, would depend on the locations of management actions. Impact determinations for each special-status species are shown in Appendix E.

Conclusion

Negligible to small adverse impacts from vegetation and predator management activities and habitat creation management actions during construction could occur to other special-status species. Mechanical ESH and early life stage pallid sturgeon habitat construction would result in direct and indirect, temporary, negligible adverse impacts to whooping cranes, bald eagles,

northern long-eared bats, and Indiana bats. Vegetation and predator management could result in temporary, negligible, adverse impacts to bald eagles, which may forage in sandbar habitat. However, these actions are not anticipated to impact whooping cranes, northern long-eared bats, Indiana bats, or western prairie fringed orchids because these species are not associated with sandbar habitat. Long-term, large beneficial impacts would occur from land acquisition, habitat development, and habitat creation management actions. Based on the expected impacts from Alternative 1, management actions are not anticipated to have the potential to result in significant impacts on other special-status species.

3.6.2.5 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Potential impacts to special-status species from management actions implemented under Alternative 2 are similar to those described under Alternative 1, including mechanical construction of ESH and channel reconfiguration for creation of early life stage pallid sturgeon habitat. However, under Alternative 2, mechanical ESH construction in the upper basin would occur at an average rate of 3,546 acres per year, and in addition to occurring in the Garrison and Gavins Point reaches, would occur in the Fort Randall and Lewis and Clark Lake reaches. A total of 10,758 acres of early life stage pallid sturgeon habitat would be constructed. Land acquisition requirements for early life stage pallid sturgeon habitat construction would result in the acquisition and management of 45,716 acres of land in the lower river basin (3,234 acres from Ponca to Sioux city; 7,123 acres from Sioux City to Platte River; 5,198 acres from Platte River to Rulo; 15,285 acres from Rulo to Kansas River; 14,876 acres from Kansas River to Osage River).

In addition to the activities included under Alternative 1, Alternative 2 includes spring pallid sturgeon flow releases out of Gavins Point Dam and a low nesting season reservoir release. Impacts to special-status species under Alternative 2 would also include habitat development and land management on MRRP lands as well as those described in Section 3.6.2.3, Impacts from Management Actions Common to All Alternatives. Potential impacts of Alternative 2 on each species are described below.

Whooping Crane

Alternative 2 would have both adverse and beneficial impacts to the whooping crane. Mechanical ESH construction would have temporary direct adverse impacts to whooping cranes during construction, similar to those described under Alternative 1. However, these impacts would be greater under Alternative 2 because ESH construction would occur at a much higher rate.

Channel reconfiguration for creation of early life stage pallid sturgeon habitat would have no impact on whooping cranes because these actions would occur outside the typical range for this species. Similarly, land acquisition would occur outside the typical range of whooping cranes and would have no impact on this species.

Flow actions to be implemented under Alternative 2 would result in a slight increasing trend (4 percent) in emergent wetland habitat within the upper river basin based on EQ account modeling results which are described in detail in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org). This increase would result in a beneficial long-term impact for whooping cranes. This impact would be negligible compared to Alternative 1 due to the small potential increase in wetland habitat. Continued management of the System and inundation of floodplain connectivity to wetlands

could result in long-term, beneficial impacts to whooping cranes increasing the quality of foraging habitat.

Direct, adverse impacts to whooping cranes during habitat construction and maintenance would be negligible because displaced individuals would likely use adjacent habitats temporarily and return to the area once maintenance crews and equipment are removed. Therefore, adverse impacts are not expected to be significant. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts to whooping cranes if habitats are improved or additional habitats are created. Specific impacts would depend on the locations of management actions.

Bald Eagle

Impacts to bald eagles under Alternative 2 would be both beneficial and adverse. Adverse, disturbance-related impacts to bald eagles would include temporary displacement of individuals due to ESH and early life stage pallid sturgeon habitat construction activities, as described under Alternative 1. However, these impacts would be greater under Alternative 2 because ESH construction would occur at a much higher rate and more early life stage pallid sturgeon habitat would be created. Impacts associated with ESH construction and maintenance activities would be limited to the upper river basin, while impacts from early life stage pallid sturgeon habitat construction would be limited to the lower river basin. Bald eagles could also be impacted by any action that results in the disturbance or removal of mature trees, which could serve as roosting or nesting sites along the riparian corridor. Specific impacts would depend on the locations of management actions.

Flow actions to be implemented under Alternative 2 would result in an increasing trend (9 percent) in riparian woodland/forested wetland habitat throughout the geographic scope of the MRRMP-EIS based on EQ account modeling results which are described in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org). This increase would result in a beneficial, long-term, small impact for bald eagles compared to Alternative 1. Bald eagles could also use open water and upland grassland habitats for foraging. However, any impacts to these habitats would be negligible due to the vast amount of foraging habitat available throughout the region.

The acquisition and management of additional lands, required for early life stage pallid sturgeon habitat construction would result in direct, beneficial, long-term impacts to bald eagles. These impacts would be large compared to Alternative 1. Human restriction measures on ESH could also contribute long-term benefits to bald eagles in the upper river basin, as described above. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts if habitats are improved or additional habitats are created.

Northern Long-Eared Bat

Impacts that would occur as a result of mechanical ESH construction and early life stage pallid sturgeon habitat construction would be similar to those described under Alternative 1. However, these impacts would be greater under Alternative 2 because ESH construction would occur at a much higher rate and more early life stage pallid sturgeon habitat would be created. Adverse impacts would occur if mature trees are removed, which could serve as roosting or nesting sites.

When compared to Alternative 1, the spawning cue releases and low-nesting season reservoir releases would likely have no impact to the northern long-eared bat in the upper river and a beneficial, long-term, small impact in the lower river. These flows would result in a decreasing trend (−1 percent) in both riparian woodland/forested wetland and forest habitat in the upper river and a positive trend (21 percent) in the lower river based on EQ account modeling results which are described in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org). Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts if habitats are improved or additional habitats are created. Alternative 2 would potentially result in a negligible adverse and a long-term, small beneficial impact for northern long-eared bats compared to Alternative 1.

Indiana Bat

Potential impacts from early life stage pallid sturgeon habitat construction would be similar to those described under Alternative 1. However, these impacts would be greater under Alternative 2 because more early life stage pallid sturgeon habitat would be created. Adverse impacts would occur if mature trees, which could serve as roosting or nesting sites, are removed.

When compared to Alternative 1, flow actions under Alternative 2 will likely have a beneficial, long-term, small impact in the lower river. The spawning cue releases and low nesting season flow would result in a positive increasing trend (21 percent) in riparian woodland/forested wetland and forest habitat in the lower river based on EQ account modeling results which are described in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

The acquisition and management of additional lands, required for early life stage pallid sturgeon habitat construction, would result in direct, beneficial, long-term impacts to Indiana bats. These impacts would be large compared to Alternative 1. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts if habitats are improved or additional habitats are created. Alternative 2 would potentially result in a negligible, adverse and a long-term, large, and beneficial impact for Indiana bats compared to Alternative 1.

Western Prairie Fringed Orchid

Alternative 2 would only result in adverse impacts to the western prairie fringed orchid if plants are crushed by construction equipment traversing the area to access construction or maintenance sites. The majority of unplowed prairie habitat remaining along the Missouri River is relatively small. Specific impacts would depend on the locations of management actions. Any lands acquired for habitat development and land management that are suitable habitat for western prairie fringed orchid would be protected and would benefit the species. These beneficial impacts would be negligible as most lands acquired would most likely be previously plowed/disturbed/accredited lands that are likely not suitable habitat for western prairie fringed orchid.

Other Special-Status Species

Under Alternative 2, direct and indirect adverse impacts to other special-status species would be similar to those described in Section 3.5, Fish and Wildlife Habitat and would be commensurate with impact changes in habitat type due to flow actions to be implemented under Alternative 2. Direct or indirect adverse impacts could be temporary or permanent and would

have the greatest impact on aquatic species because these actions would require in-water work resulting in temporary increases in turbidity and sedimentation and modification of existing aquatic habitats.

Land acquisition and habitat development and land management on MRRP lands would have direct and indirect, long-term, large, beneficial impacts on other special-status species because lands adjacent to the Missouri River would be acquired and managed for conservation. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts if habitats are improved or additional habitats are created. The type, duration, and intensity of all impacts, as well as specific species which could be impacted, would depend on the locations of management actions. Impact determinations for each special-status species are shown in Appendix E.

Conclusion

Negligible to small adverse impacts from vegetation and predator management activities and habitat creation management actions could occur during construction to other special-status species compared to Alternative 1. Similar to Alternative 1, mechanical ESH and early life stage pallid sturgeon habitat construction would result in direct and indirect, temporary, negligible adverse impacts to whooping cranes, bald eagles, northern long-eared bats, and Indiana bats. Vegetation and predator management could result in temporary, negligible, adverse impacts to bald eagles, which may forage in sandbar habitat. However, these actions are not anticipated to impact whooping cranes, northern long-eared bats, Indiana bats, or western prairie fringed orchids because these species are not associated with sandbar habitat. Emergent wetland and woodland/forested wetland habitats would have an increasing trend in all reaches and forest habitat would have an increasing trend in the lower river under Alternative 2 compared to Alternative 1. These habitat trends would result in negligible adverse impacts to northern-long eared bats in the upper river, and long-term beneficial impacts in the lower river. Habitat trends would result in long-term beneficial impacts to whooping cranes, bald eagles, and Indiana bats, wherever found. Long-term, beneficial impacts would occur from land acquisition and habitat development; and habitat creation management actions that would provide habitat would be beneficial with long-term large impacts. Based on the expected level of impact, management actions are not anticipated to have the potential to result in significant impacts on other special-status species under Alternative 2.

3.6.2.6 Alternative 3 – Mechanical Construction Only

Alternative 3 consists of mechanical habitat construction only. Potential impacts to special-status species from ESH construction under Alternative 3 would be similar to those described under Alternative 1. However, under Alternative 3, mechanical ESH construction in the upper basin would occur at an average rate of 391 acres per year in years where construction is needed, and in addition to occurring in the Garrison and Gavins Point reaches, would occur in the Fort Randall reach.

Impacts from channel reconfiguration for the creation of early life stage pallid sturgeon habitat would also be similar to those described under Alternative 1, but up to 3,380 acres of new early life stage pallid sturgeon habitat would be constructed under Alternative 3. Land acquisition requirements for early life stage pallid sturgeon habitat construction would result in the acquisition and management of 1,772 acres of land in the lower river basin (1,664 acres from Rulo to Kansas River; 108 acres from Kansas River to Osage River).

Alternative 3 would also include spawning habitat construction. Spawning habitat construction and channel reconfiguration for interception and rearing complexes would require in-water work, and impacts would be similar to those described for mechanical ESH construction and early life stage pallid sturgeon habitat construction under Alternative 1. Impacts from these actions would be limited to reaches within the lower river basin.

Impacts to special-status species under Alternative 3 would also include habitat development and land management on MRRP lands as well as those described in Section 3.6.2.3, Impacts from Management Actions Common to All Alternatives. Potential impacts of Alternative 3 on each species are described below.

Whooping Crane

Under Alternative 3, impacts to the whooping crane would be similar to those described under Alternative 1. Mechanical ESH construction would have temporary direct adverse impacts to whooping cranes, but these impacts would be slightly greater under Alternative 3 because ESH construction would occur at a higher rate, compared to Alternative 1. Potential impacts would be limited to emergent wetlands adjacent to the upper river, and would only occur during fall migration.

Channel reconfiguration for creation of early life stage pallid sturgeon habitat and spawning habitat construction would have no impact on whooping cranes because these actions would occur outside the typical range for this species. Similarly, land acquisition would occur outside the typical range of whooping cranes, and would have no impact on this species.

Alternative 3 would result in a slight increasing trend (1 percent) in emergent wetland habitat within the upper river based on EQ account modeling results, which are described in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org). This increase would result in a beneficial long-term impact for whooping cranes compared to Alternative 1. This impact would be negligible due to the small potential increase in emergent wetland habitat.

Direct adverse impacts during habitat construction to whooping cranes would be negligible because displaced individuals would likely use adjacent habitats temporarily, and return to the area once maintenance crews and equipment are removed. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts to whooping cranes if habitats are improved or additional habitats are created. Specific impacts would depend on the locations of management actions.

Bald Eagle

Direct adverse impacts to bald eagles would include temporary displacement of individuals due to ESH and early life stage pallid sturgeon habitat construction activities, as described under Alternative 1. However, these impacts would be greater under Alternative 3 because ESH construction would occur at a much higher rate. Impacts associated with ESH construction and maintenance activities would be limited to the upper river basin, while impacts from early life stage pallid sturgeon habitat construction would be limited to the lower river basin. Bald eagles could also be impacted by any action that results in the disturbance or removal of mature trees along the riparian corridor, which could serve as roosting or nesting sites.

Channel reconfiguration for creation of early life stage pallid sturgeon habitat and spawning habitat construction could result in adverse or beneficial impact to bald eagles, if riparian/forested wetland habitat is decreased or increased, respectively.

Adverse impacts to the bald eagle under Alternative 3 would be negligible because displaced individuals would likely return upon completion of construction and maintenance activities or relocate to adjacent habitats. Specific impacts would depend on the locations of management actions.

Alternative 3 would result in an increasing trend (9 percent) in riparian woodland/forested wetland habitat throughout the geographic scope of the EIS based on EQ account modeling results, which are described in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org). This increase would result in a small, long-term beneficial impact for bald eagles compared to Alternative 1. Bald eagles could also use open water and upland grassland habitats for foraging. However, any impacts to these habitats would be negligible due to the vast amount of foraging habitat available throughout the region. Bald eagles would benefit from the acquisition and management of additional land. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts if habitats are improved or additional habitats are created.

Northern Long-Eared Bat

Alternative 3 would have both potential adverse and beneficial impacts to the northern long-eared bat. Impacts that would occur as a result of mechanical ESH construction and early life stage pallid sturgeon habitat construction would be similar to those described under Alternative 1. However, these impacts would be slightly greater under Alternative 3 because ESH construction would occur at a higher rate, compared to Alternative 1. Adverse impacts would occur if mature trees, which may serve as roosting or nesting sites, are removed.

Channel reconfiguration for creation early life stage pallid sturgeon habitat and spawning habitat construction could result in adverse or beneficial impacts to northern long-eared bats, if riparian/forested wetland habitat is decreased or increased, respectively.

When compared to Alternative 1, Alternative 3 would have negligible impacts to the northern long-eared bat in the upper river and a small, long-term beneficial impact in the lower river. A downward trend (−4 percent) in riparian woodland/forested wetland and forest habitat in the upper river and a positive increasing trend (10 percent) in the lower river would occur throughout the geographic scope of the MRRMP-EIS based on EQ account modeling results, which are described in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org). The acquisition and management of additional land would result in negligible long-term beneficial impacts. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts if habitats are improved or additional habitats are created.

Indiana Bat

Mechanical ESH construction would not occur within the range of the Indiana bat, and thus, would have no impacts to this species. Potential impacts from early life stage pallid sturgeon habitat construction would be similar to those described under Alternative 1.

Channel reconfiguration for creation of early life stage pallid sturgeon habitat and spawning habitat construction could result in adverse or beneficial impacts to Indiana bats if riparian/forested wetland habitat is decreased or increased, respectively.

When compared to Alternative 1, Alternative 3 would have a beneficial, long-term, small impact to the Indiana bat. Alternative 3 would result in a positive increasing trend (10 percent) in riparian woodland/forested wetland and forest habitat in the lower river based on EQ account modeling results. The acquisition and management of additional land would result in negligible long-term beneficial impacts. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts if habitats are improved or additional habitats are created.

Western Prairie Fringed Orchid

Alternative 3 would only result in adverse impacts to the western prairie fringed orchid if plants are crushed by construction equipment traversing the area to access construction or maintenance sites. The majority of unplowed prairie habitat remaining along the Missouri River is relatively small. Specific impacts would depend on the locations of management actions. Any lands acquired for habitat development and land management that are suitable habitat for western prairie fringed orchid would be protected and would benefit the species. These beneficial impacts would be negligible as most lands acquired would most likely be previously plowed/disturbed/accredited lands that are likely not suitable habitat for western prairie fringed orchid.

Other Special-Status Species

Under Alternative 3, direct and indirect adverse impacts to other special-status species would be commensurate with impact changes in habitat type due to mechanical ESH construction under Alternative 3. Adverse impacts could be temporary or permanent and would have the greatest impact on aquatic species because these actions would require in-water work resulting in temporary increases in turbidity, sedimentation, and modification of existing aquatic habitats. Special-status species which use ESH habitat (birds) could benefit in the long-term because mechanical ESH construction under Alternative 3 will result in a net increase in this habitat type. Acquisition of additional lands would also benefit special-status species which could inhabit acquired lands. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts if habitats are improved or additional habitats are created. These impacts would be negligible compared to Alternative 1. The type, duration, and intensity of all impacts, as well as specific species which could be impacted, would depend on the locations of management actions. Impact determinations for each special-status species are shown in Appendix E.

Conclusion

Negligible to small adverse impacts from vegetation and predator management activities and habitat creation management actions during construction could occur to other special-status species compared to Alternative 1. Similar to Alternative 1, mechanical ESH and early life stage pallid sturgeon habitat construction would result in direct and indirect, temporary, negligible adverse impacts to whooping cranes, bald eagles, and northern long-eared bats. Vegetation and predator management could result in temporary, negligible, adverse impacts to bald eagles, which may forage in sandbar habitat. However, these actions are not anticipated to impact whooping cranes, northern long-eared bats, Indiana bats, or western prairie fringed orchids

because these species are not associated with sandbar habitat. Emergent wetland and woodland/forested wetland habitats would have an increasing trend in all reaches and forest habitat would have an increasing trend in the lower river under Alternative 3 compared to Alternative 1. These increasing habitat trends would have long-term beneficial impacts on whooping cranes, bald eagles, northern long-eared bats, and Indiana bats. Long-term beneficial impacts would occur from land acquisition and habitat development and habitat creation management actions that would provide habitat would be beneficial with long-term large impacts. Impacts from management actions are not anticipated to have the potential to result in significant impacts on other special-status species under Alternative 3.

3.6.2.7 Alternative 4 – Spring ESH Creating Release

Alternative 4 consists of a spring release for the creation of ESH habitat as well as mechanical ESH construction and early life stage pallid sturgeon habitat construction. Potential impacts to special-status species from ESH construction under Alternative 4 would be similar to those described under Alternative 1. However, under Alternative 4, mechanical ESH construction in the upper basin would occur at an average rate of 240 acres per year in years where construction is needed and in addition to occurring in the Garrison and Gavins Point reaches would occur in the Fort Randall reach. Impacts from channel reconfiguration for creation of early life stage pallid sturgeon habitat and associated land acquisition would be the same as described under Alternative 3. Alternative 4 would also include spawning habitat construction as described under Alternative 3.

Impacts to special-status species under Alternative 4 would also include habitat development and land management on MRRP lands as well as those described in Section 3.6.2.3, Impacts from Management Actions Common to All Alternatives. Potential impacts of Alternative 4 on each species are described below.

Whooping Crane

Temporary direct adverse impacts to whooping cranes from mechanical ESH construction would be the same as those described under Alternative 1, but these impacts would be slightly greater under Alternative 4 because ESH construction would occur at a higher rate. Potential impacts would be limited to emergent wetlands adjacent to the upper river, and would only potentially occur during fall migration.

Impacts to whooping cranes as a result of channel reconfiguration for creation of early life stage pallid sturgeon habitat, spawning habitat construction, and land acquisition would be the same as those described under Alternative 3.

Spring reservoir release under Alternative 4 would result in a slight decreasing trend (−6 percent) in emergent wetland habitat within the upper river based on EQ account modeling results, which are described in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org). This increase would result in a long-term, adverse impact for whooping cranes compared to Alternative 1. This impact would be negligible due to the small potential decrease in emergent wetland habitat.

Adverse impacts to whooping cranes under Alternative 4 would be direct, temporary, and negligible because displaced individuals would likely return upon completion of construction and maintenance activities or relocate to adjacent habitats. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts to whooping

cranes if habitats are improved or additional habitats are created. Specific impacts would depend on the locations of management actions.

Bald Eagle

Direct adverse impacts to bald eagles due to mechanical ESH construction would be the same as those described under Alternative 1, but these impacts would be slightly greater under Alternative 4 because ESH construction would occur at a higher rate. Impacts from early life stage pallid sturgeon habitat construction and associated land acquisition would be the same as those described under Alternative 3.

Impacts to bald eagles from channel reconfiguration for creation of early life stage pallid sturgeon habitat and spawning habitat construction would be the same as those described under Alternative 3.

Spring reservoir release under Alternative 4 would result in a slight increasing trend (5 percent) in riparian woodland/forested wetland habitat throughout the geographic scope of the MRRMP-EIS based on EQ account modeling results, which are described in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org). This increase would result in a beneficial, long-term, small impact for bald eagles compared to Alternative 1. However, any impacts to these habitats would be negligible due to the vast amount of foraging habitat throughout the region. Bald eagles would also benefit from the acquisition and management of additional land. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts if habitats are improved or additional habitats are created.

Northern Long-Eared Bat

Direct adverse impacts due to mechanical ESH construction would be the same as those described under Alternative 1, but these impacts would be slightly greater under Alternative 4 because ESH construction would occur at a higher rate. Impacts from early life stage pallid sturgeon habitat construction and associated land acquisition would be the same as those described under Alternative 3. Adverse impacts would occur if mature trees, which may serve as roosting or nesting sites, are removed.

Impacts from channel reconfiguration for creation of pallid sturgeon early life stage habitat and spawning habitat construction would be the same as those described under Alternative 3.

When compared to Alternative 1, Alternative 4 will have negligible impacts to the northern long-eared bat in the upper river and a beneficial, long-term, small impact in the lower river. Spring reservoir releases for ESH creation would result in no change (zero percent) in riparian woodland/forested wetland and forest habitat in the upper river and a positive increasing trend (14 percent) in the lower river based on EQ account modeling results, which are described in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org). These changes would result in an overall long-term, small, and beneficial impact for northern long-eared bats compared to Alternative 1. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts if habitats are improved or additional habitats are created.

Indiana Bat

Mechanical ESH construction would not occur within the range of the Indiana bat, and thus, would have no impacts to this species. Potential impacts from early life stage pallid sturgeon habitat construction would be similar to those described under Alternative 1.

Impacts from channel reconfiguration for creation of early life stage habitat and spawning habitat construction would be the same as those described under Alternative 3.

When compared to Alternative 1, Alternative 4 would have a beneficial, long-term, small impact to the Indiana bat. Spring reservoir releases for ESH creation would result in a positive increasing trend (14 percent) in riparian woodland/forested wetland and forest habitat in the lower river based on EQ account modeling results. These changes would result in a long-term, negligible small adverse and a long-term, small beneficial impact for northern long-eared bats compared to Alternative 1. The acquisition and management of additional land would result in negligible long-term beneficial impacts. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts if habitats are improved or additional habitats are created.

Western Prairie Fringed Orchid

Impacts would be the same as described for Alternative 3.

Other Special-Status Species

Spring reservoir releases for ESH creation under Alternative 4 would have little effect on the number of acres of most habitat types but would result in a slight increase in riparian woodland/forested wetland and forest habitat and a slight decrease in upland grassland habitat. Additionally, special-status species which use ESH habitat (birds) could benefit in the long-term because mechanical ESH construction under Alternative 4 would result in a net increase in ESH habitat. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts if habitats are improved or additional habitats are created.

Conclusion

Negligible to small adverse impacts from vegetation and predator management activities and habitat creation management actions during construction could occur to other special-status species compared to Alternative 1. ESH creation would result in direct and indirect, temporary, negligible adverse impacts to whooping cranes, bald eagles, and northern long-eared bats. Similar to Alternative 1, vegetation and predator management could result in temporary, negligible, adverse impacts to bald eagles, which may forage in sandbar habitat. However, these actions are not anticipated to impact whooping cranes, northern long-eared bats, Indiana bats, or western prairie fringed orchids because these species are not associated with sandbar habitat. Woodland/forested wetland habitat would have an increasing trend and emergent wetland habitat would have a decreasing trend in all reaches and forest habitat would have an increasing trend in the lower river under Alternative 4 compared to Alternative 1. These habitat trends would have long-term negligible adverse impacts on whooping cranes and long-term beneficial impacts on bald eagles, northern long-eared bats, and Indiana bats. Long-term, beneficial impacts would occur from land acquisition and habitat development. Habitat creation management actions would be beneficial with long-term, large impacts.

3.6.2.8 Alternative 5 – Fall ESH Creating Release

Alternative 5 would be similar to Alternative 1 but with the addition of a high fall release designed to create ESH. Potential impacts to special-status species from ESH construction under Alternative 5 would be the same as those described for Alternative 3. However, under Alternative 5, mechanical ESH construction in the upper basin would occur at an average rate of 309 acres per year in years where construction is needed and, in addition to occurring in the Garrison and Gavins Point reaches, would also occur in the Fort Randall reach. Impacts from channel reconfiguration for creation of early life stage pallid sturgeon habitat and associated land acquisition would be the same as described under Alternative 3. Alternative 5 would also include spawning habitat construction as described under Alternative 3.

Impacts to special-status species under Alternative 5 would also include habitat development and land management on MRRP lands as well as those described in Section 3.6.2.3, Impacts from Management Actions Common to All Alternatives. Potential impacts of Alternative 5 on each species are described below.

Whooping Crane

Temporary direct adverse impacts to whooping cranes from mechanical ESH construction would be the same as those described under Alternative 1, but these impacts would be slightly greater under Alternative 5 because ESH construction would occur at a higher rate. Potential impacts would be limited to emergent wetlands adjacent to the upper river and would only potentially occur during fall migration.

Impacts to whooping cranes as a result of channel reconfiguration for creation of early life stage pallid sturgeon habitat, spawning habitat construction, and land acquisition would be the same as those described under Alternative 3.

Fall reservoir releases for ESH creation under Alternative 5 would result in a slight increasing trend (4 percent) in emergent wetland within the upper river based on EQ account modeling results. This increase would result in a beneficial long-term impact for whooping cranes compared to Alternative 1. However, this impact would be negligible due to the small potential increase in emergent wetland habitat. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts to whooping cranes if habitats are improved or additional habitats are created. Specific impacts would depend on the locations of management actions.

Bald Eagle

Impacts to bald eagles under Alternative 5 would be both beneficial and adverse. Direct, adverse impacts to bald eagles due to mechanical ESH construction would be the same as those described under Alternative 1, but these impacts would be slightly greater under Alternative 5 because ESH construction would occur at a higher rate. Impacts from early life stage pallid sturgeon habitat construction and associated land acquisition would be the same as those described under Alternative 3.

Impacts to bald eagles from channel reconfiguration for creation of early life stage pallid sturgeon habitat and spawning habitat construction would be the same as those described under Alternative 3.

Direct and indirect, adverse impacts to the bald eagle under Alternative 5 would negligible because displaced individuals would likely return upon completion of construction and maintenance activities or relocate to adjacent habitats. Specific impacts would depend on the locations of management actions.

Fall reservoir releases for ESH construction under Alternative 5 would result in a slight increasing trend (9 percent) in riparian woodland/forested wetland habitat throughout the geographic scope of the MRRMP-EIS based on EQ account modeling results. This increase would result in a beneficial, long-term, small impact for bald eagles compared to Alternative 1. However, any impacts to these habitats would be negligible due to the vast amount of foraging habitat throughout the region. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts if habitats are improved or additional habitats are created.

Northern Long-Eared Bat

Direct adverse impacts due to mechanical ESH construction would be the same as those described under Alternative 1, but these impacts would be slightly greater under Alternative 5 because ESH construction would occur at a higher rate. Impacts from early life stage pallid sturgeon habitat construction and associated land acquisition would be the same as those described under Alternative 3. Adverse impacts would occur if mature trees, which may serve as roosting or nesting sites, are removed.

Impacts from channel reconfiguration for creation of early life stage pallid sturgeon habitat and spawning habitat construction would be the same as those described under Alternative 3.

When compared to Alternative 1, Alternative 5 will have negligible impact to the northern long-eared bat in the upper river and a beneficial, long-term, small impact in the lower river. Fall reservoir releases for ESH construction would result in a negligible downward trend (−4 percent) in riparian woodland/forested wetland and forest habitat in the upper river and a positive increasing trend (9 percent) in the lower river based on EQ account modeling results. These changes would result in a negligible adverse and a long-term, small beneficial impact for northern long-eared bats compared to Alternative 1. The acquisition and management of additional land would result in negligible long-term beneficial impacts. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts if habitats are improved or additional habitats are created.

Indiana Bat

Mechanical ESH construction would not occur within the range of the Indiana bat, and thus, would have no impacts to this species. Potential impacts from early life stage pallid sturgeon habitat construction would be similar to those described under Alternative 1.

Impacts from channel reconfiguration for creation of early life stage pallid sturgeon habitat and spawning habitat construction would be the same as those described under Alternative 3.

When compared to Alternative 1, Alternative 5 will have a beneficial, long-term, small impact to the Indiana bat. Fall reservoir releases for ESH creation would result in a positive increasing trend (9 percent) in riparian woodland/forested wetland and forest habitat in the lower river based on EQ account modeling results. This would result in a long-term, small beneficial impact to Indiana bats. The acquisition and management of additional land would result in negligible

long-term beneficial impacts. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts if habitats are improved or additional habitats are created.

Western Prairie Fringed Orchid

Impacts would be the same as described for Alternative 3.

Other Special-Status Species

Under Alternative 5, direct and indirect adverse impacts to other special-status species would be similar to those described under Alternative 4 due to the similarity of changes in various habitat types. All impacts to special-status species would be commensurate with impact changes in habitat type due to flow actions to be implemented under Alternative 5. Impact determinations for each special-status species are shown in Appendix E.

Conclusion

Negligible to small adverse impacts from vegetation and predator management activities and habitat creation management actions during construction could occur to other special-status species compared to Alternative 1. ESH creation would result in direct and indirect, temporary, negligible adverse impacts to whooping cranes, bald eagles, and northern long-eared bats. Similar to Alternative 1, vegetation and predator management could result in temporary, negligible, adverse impacts to bald eagles, which may forage in sandbar habitat. However, these actions are not anticipated to impact whooping cranes, northern long-eared bats, Indiana bats, or western prairie fringed orchids because these species are not associated with sandbar habitat. Emergent wetland and woodland/forested wetland habitats would have an increasing trend in all reaches and forest habitat would have an increasing trend in the lower river under Alternative 5 compared to Alternative 1. These habitat trends would result in negligible adverse impacts to northern-long eared bats in the upper river, and long-term beneficial impacts in the lower river. Habitat trends would result in long-term beneficial impacts to whooping cranes, bald eagles, and Indiana bats, wherever found. Long-term, beneficial impacts would occur from land acquisition and habitat development; habitat creation management actions that would provide habitat would be beneficial with long-term, large impacts. Impacts from management actions are not anticipated to have the potential to result in significant impacts on other special-status species under Alternative 5.

3.6.2.9 Alternative 6 – Pallid Sturgeon Spawning Cue

Alternative 6 would be similar to Alternative 1 but with the addition of spawning cue releases. Potential impacts to special-status species from ESH construction under Alternative 6 would be similar to those described under Alternative 1. However, under Alternative 6, mechanical ESH construction in the upper basin would occur at an average rate of 303 acres per year in years where construction is needed and, in addition to occurring in the Garrison and Gavins Point reaches, would occur in the Fort Randall reach. Impacts from channel reconfiguration for the creation of early life stage pallid sturgeon habitat and associated land acquisition would be the same as described under Alternative 3. Alternative 6 would also include spawning habitat construction as described under Alternative 3.

Impacts to special-status species under Alternative 6 would also include habitat development and land management on MRRP lands as well as those described in Section 3.6.2.3, Impacts

from Management Actions Common to All Alternatives. Potential impacts of Alternative 5 on each species are described below.

Whooping Crane

Temporary direct adverse impacts to whooping cranes from mechanical ESH construction would be the same as those described under Alternative 1, but these impacts would be slightly greater under Alternative 6 because ESH construction would occur at a higher rate. Potential impacts would be limited to emergent wetlands adjacent to the upper river and would only potentially occur during fall migration.

Impacts to whooping cranes as a result of channel reconfiguration for creation of early life stage pallid sturgeon habitat, spawning habitat construction, and land acquisition would be the same as those described under Alternative 3.

Flow actions to be implemented under Alternative 6 would result in a slight increasing trend (3 percent) in emergent wetland habitat within the upper river based on EQ account modeling results. This increase would result in a beneficial long-term impact for whooping cranes compared to Alternative 1. This impact would be negligible due to the small potential increase in emergent wetland habitat. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts to whooping cranes if habitats are improved or additional habitats are created. Specific impacts would depend on the locations of management actions.

Bald Eagle

Direct adverse impacts to bald eagles due to mechanical ESH construction would be the same as those described under Alternative 1, but these impacts would be slightly greater under Alternative 6 because ESH construction would occur at a higher rate. Impacts from early life stage pallid sturgeon habitat construction and associated land acquisition would be the same as those described under Alternative 3.

Impacts to bald eagles from channel reconfiguration for creation of early life stage pallid sturgeon habitat and spawning habitat construction would be the same as those described under Alternative 3.

Flow actions to be implemented under Alternative 6 would result in a slight increasing trend (5 percent) in riparian woodland/forested wetland habitat throughout the geographic scope of the MRRMP-EIS based on EQ account modeling results. This increase would result in a beneficial, long-term, small impact for bald eagles compared to Alternative 1. Bald eagles could also use open water and upland grassland habitats for foraging. However, any impacts to these habitats would be negligible due to the vast amount of foraging habitat throughout the region. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts if habitats are improved or additional habitats are created.

Northern Long-Eared Bat

Direct adverse impacts due to mechanical ESH construction would be the same as those described under Alternative 1, but these impacts would be slightly greater under Alternative 6 because ESH construction would occur at a higher rate. Impacts from early life stage pallid sturgeon habitat construction and associated land acquisition would be the same as those

described under Alternative 3. Adverse impacts would occur if mature trees, which may serve as roosting or nesting sites, are removed.

Impacts from channel reconfiguration for creation of early life stage pallid sturgeon habitat and spawning habitat construction would be the same as those described under Alternative 3.

A March and May spawning cue release attempted every three years would result in a negligible downward trend (−9 percent) in riparian woodland/forested wetland and forest habitat in the upper river and a positive increasing trend (8 percent) in the lower river based on EQ account modeling results. This would result in a long-term, small beneficial impact to northern long-eared bats. The acquisition and management of additional land would result in negligible long-term beneficial impacts. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts if habitats are improved or additional habitats are created.

Indiana Bat

Mechanical ESH construction would not occur within the range of the Indiana bat and, therefore, would have no impacts to this species. Potential impact from early life stage pallid sturgeon habitat construction would be similar to those described under Alternative 1.

Impacts from channel reconfiguration for creation of early life stage pallid sturgeon habitat and spawning habitat construction would be the same as those described under Alternative 3.

When compared to Alternative 1, Alternative 6 would have a beneficial, long-term, small impact to the Indiana bat. A March and May spawning cue release attempted every three years would result in a positive increasing trend (6 percent) in the lower river based on EQ account modeling results. This would result in a long-term, small beneficial impact to Indiana bats. The acquisition and management of additional land would result in negligible long-term beneficial impacts. Habitat development and land management on MRRP lands could result in direct, beneficial, long-term impacts if habitats are improved or additional habitats are created.

Western Prairie Fringed Orchid

Impacts would be the same as described for Alternative 3.

Other Special-Status Species

Under Alternative 6, direct and indirect adverse or beneficial impacts to other special-status species would be similar to those described for Alternatives 3−5. All impacts to special-status species would be commensurate with impact changes in habitat type due to flow actions to be implemented under Alternative 6. Impact determinations for each species are shown in Appendix E.

Conclusion

Negligible to small adverse impacts from vegetation and predator management activities and habitat creation management actions during construction could occur to other special-status species compared to Alternative 1. ESH creation would result in direct and indirect, temporary, negligible adverse impacts to whooping cranes, bald eagles, and northern long-eared bats. Similar to Alterative 1, vegetation and predator management could result in temporary, negligible, adverse impacts to bald eagles, which may forage in sandbar habitat. However,

these actions are not anticipated to impact whooping cranes, northern long-eared bats, Indiana bats, or western prairie fringed orchids because these species are not associated with sandbar habitat. Emergent wetland and woodland/forested wetland habitats would have an increasing trend in all reaches and forest habitat would have an increasing trend in the lower river under Alternative 6 compared to Alternative 1. These habitat trends would result in negligible adverse impacts to northern-long eared bats in the upper river, and long-term beneficial impacts in the lower river. Habitat trends would result in long-term beneficial impacts to whooping cranes, bald eagles, and Indiana bats, wherever found. Long-term, beneficial impacts would occur from land acquisition and habitat development; habitat creation management actions that would provide habitat would be beneficial with long-term large impacts. Impacts from management actions are not anticipated to have the potential to result in significant impacts on other special-status species under Alternative 6.

3.6.2.10 Tribal Resources

Some plants and animals are of great cultural importance to the Tribes and have fundamental roles in diet, materials, medicine, and/or spiritual practices. Of the five special-status species carried forward for detailed analysis the bald eagle and whooping crane were identified as species of Tribal interest. Impacts to these species from each alternative were described previously.

3.6.2.11 Climate Change

As described in Section 3.5, Fish and Wildlife Habitat, the influence of climate change to fish and wildlife may be beneficial, neutral, or adverse and may change over time, depending on the habitat or species and other relevant considerations, and could cause changes in individual habitat classes used by other special-status species. Changes in acres of individual habitat classes as modeled for the POR caused by management actions under each of the alternatives described above could exacerbate impacts to other special-status species expected to occur from climate change.

An increase in the frequency of spring pulses or flooding that would inundate other special-status species habitat more frequently could cause changes in the acres of individual habitat classes with increases in wetter habitats (i.e., open water, emergent wetland, scrub shrub wetland, and riparian woodland/forested wetland) and decreases in drier habitats (i.e., forest and upland grassland) if precipitation and streamflow increase. These potential changes in acres of habitat classes would be minimized if the frequency of a completed pulse decreases due to exceeding flood targets more frequently if precipitation and streamflow increase. Maintenance of aquatic habitats could also occur more frequently sustaining important breeding and foraging habitat for other special-status species. Decreases in the frequency of spring pulses, increased drought conditions, or decreased frequency of all pulses due to decreased System storage from increased sedimentation could have the opposite effect (i.e., increases in drier habitats and decreases in wetter habitats).

A change in events, such as flow pulses or frequency of flooding and drought conditions, that does not correlate to the life history events (e.g., breeding, hatching, and flowering) of special-status species on which they are dependent (e.g., pollination, prey) could mean a species does not have the necessary resources available during critical periods.

It is assumed that the conclusions described for each alternative would not vary substantially under the expected climate change scenario. Therefore, the influence of climate change is not

expected to exacerbate the impacts to special-status species from any of the alternatives or their associated management actions.

3.6.2.11 Cumulative Impacts

Past, present, and reasonably foreseeable future actions, projects, and programs that could impact other special-status species include all of the actions, projects, and programs included under the cumulative impacts scenario. A summary of cumulative impacts to special-status species is presented below.

Whooping Crane

Past and present actions that have adversely impacted whooping cranes include any actions which may have resulted in loss, degradation, or fragmentation of wetland habitat in the upper Missouri River basin. These actions include floodplain development and transportation and utility corridor development. Conversion of habitat (including draining of wetlands) for agriculture and other land uses (e.g., transportation, energy development, urban, residential, commercial, and industrial) is believed to be one of the main threats to this species (Urbanek and Lewis 2015). Any past or present actions which involve construction or use of heavy equipment for maintenance may have impacted this species temporarily due to noise and visual disturbances. These actions include past construction and maintenance of the mainstem reservoir system and bank stabilization projects. Water depletions from the Missouri River for agriculture, municipal, and industrial use may have adversely impacted whooping crane habitat by reducing groundwater elevations needed to maintain healthy wetland habitats along the Missouri River floodplain.

Reasonably foreseeable future actions which may adversely impact whooping cranes include future transportation and utility corridor development, conversion of habitat for agriculture and other land uses, and water table depletion due to withdrawals from the Missouri River. These ongoing actions may result in continued loss, degradation, or fragmentation of wetland habitat within the upper Missouri River basin. Impacts of these reasonably foreseeable future actions would depend on the timing and location of specific actions. These actions are expected to result in a long-term small adverse impact to whooping cranes.

Past, present, and reasonably foreseeable future projects and actions that create, develop, and/or manage wetland habitat in the upper Missouri River basin have benefited or may benefit whooping cranes. These actions include USACE Continuing Authority Programs, USFWS National Wildlife Refuge System Lands Management, USFWS Partners for Fish and Wildlife Program, NRCS Easement Programs, NRCS Technical and Financial Assistance Programs, EPA Section 319 Non-Point Source Grant Program, and Tribal programs and actions. The actions and programs are expected to have long-term beneficial impacts to whooping cranes.

When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts associated with Alternative 1 would be both beneficial and adverse. Adverse impacts would occur primarily as a result of habitat disturbances, while beneficial impacts would occur as a result of land acquisition and habitat creation and management within the upper Missouri River basin. The implementation of Alternative 1 would provide a negligible contribution to overall cumulative impacts to whooping cranes.

Cumulative impacts for Alternatives 2–6 from other past, present, and reasonably foreseeable future actions would be the same as described for Alternative 1. While Alternative 2 would result

in similar adverse impacts to whooping cranes as those described for Alternative 1, Alternative 2 would result in a slight increasing trend (4 percent) in emergent wetland habitat within the upper river, resulting in long-term beneficial impacts. The implementation of Alternative 2 would provide a negligible contribution to overall cumulative impacts to whooping cranes. Alternative 3 would result in similar adverse impacts to whooping cranes as those described under Alternative 1, but Alternative 3 would result in a slight increasing trend (1 percent) in emergent wetland habitat within the upper river, resulting in a long-term, negligible, adverse impact. The implementation of Alternative 3 would provide a negligible contribution to overall cumulative impacts to whooping cranes.

Alternative 4 would result in nearly identical adverse and beneficial cumulative impacts to whooping cranes as those described under Alternative 3. Like Alternative 3, Alternative 4 would result in a slight decreasing trend (6 percent) in emergent wetland habitat within the upper river. When combined with other past, present, and reasonably foreseeable future actions, Alternative 4 would result in adverse and beneficial cumulative impacts largely based on changes in habitat availability, temporary habitat disturbances, land acquisition, and habitat creation and management within the upper Missouri River basin. The implementation of Alternative 4 would provide a negligible contribution to overall cumulative impacts to whooping cranes.

Alternative 5 would result in nearly identical adverse and beneficial impacts to whooping cranes as those described under Alternative 3. Like Alternative 3, Alternative 5 would result in a slight increasing trend (4 percent) in emergent wetland habitat within the upper river. The implementation of Alternative 5 would provide a negligible contribution to overall cumulative impacts to whooping cranes.

Alternative 6 would result in similar adverse and beneficial impacts to whooping cranes as those described under Alternative 3, resulting in a slight increasing trend (3 percent) in emergent wetland habitat within the upper river. When combined with other past, present, and reasonably foreseeable future actions, Alternative 6 would result in adverse and beneficial cumulative impacts. The implementation of Alternative 6 would provide a negligible contribution to overall cumulative impacts for whooping cranes.

Bald Eagle

Past or present actions that have adversely impacted bald eagles include any action which may have resulted in the loss of roosting or nesting trees along riparian corridors, or reduced the abundance of prey species. Actions which have resulted in the loss or fragmentation of riparian forest habitat include floodplain development for agriculture and other land uses, utility corridor development, construction of the mainstem reservoir system, and bank stabilization and navigation projects. Actions which may have reduced the abundance of prey resources include operation and management of the mainstem reservoir system, operation and maintenance of bank stabilization and navigation projects, and Missouri River bed degradation and aggradation. These actions have altered natural river flow, floodplain inundation, and sediment regimes, and adversely impacted habitat for many native fish and other aquatic species in the Missouri River. Operation and maintenance of the mainstem reservoir system and bank stabilization projects may temporarily impact bald eagles due to noise and visual disturbances.

Reasonably foreseeable future actions which may adversely impact bald eagles include future transportation and utility corridor development and conversion of habitat for agriculture and other land uses. These ongoing actions may result in loss, degradation, or fragmentation of bald eagle habitat. However, these impacts are expected to be negligible due the large amount of

available habitat throughout the geographic scope of the MRRMP-EIS. Past, present, and reasonably foreseeable future projects and actions that have provided or may provide long-term beneficial impacts to bald eagles by creating or managing riparian forested habitat or increasing prey abundance include fishery stocking and management, USFWS National Wildlife Refuge System Lands Management, USFWS Partners for Fish and Wildlife Program, NRCS Easement Programs, NRCS Technical and Financial Assistance Programs, EPA Section 319 Non-Point Source Grant Program, and Tribal programs and actions.

When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts associated with Alternative 1 would be both beneficial and adverse. Adverse impacts would consist of habitat disturbance and temporary displacement of individuals. Beneficial impacts would occur as a result of land acquisition and habitat creation and management. The implementation of Alternative 1 would provide a negligible contribution to overall cumulative impacts to bald eagles.

Alternative 2 would result in similar adverse cumulative impacts to bald eagles as those described under Alternative 1, but Alternative 2 would result in an increasing trend (9 percent) in riparian woodland/forested wetland habitat, resulting in long-term beneficial impacts. When combined with other past, present, and reasonably foreseeable future actions, Alternative 2 would result in adverse and beneficial cumulative impacts largely based on changes in habitat availability, temporary habitat disturbances, land acquisition, and habitat creation and management. The implementation of Alternative 2 would provide a negligible contribution to overall cumulative impacts to bald eagles.

Cumulative impacts under Alternative 3 from other past, present, and reasonably foreseeable future actions would be the same as described for Alternative 1. Adverse and beneficial impacts to bald eagles under Alternative 3 would be nearly identical to those described under Alternative 2. When combined with other past, present, and reasonably foreseeable future actions, Alternative 3 would result in adverse and beneficial cumulative impacts largely based on changes in habitat availability, temporary habitat disturbances, land acquisition, and habitat creation and management. The implementation of Alternative 3 would provide a negligible contribution to overall cumulative impacts to bald eagles.

Alternative 4 would result in similar adverse cumulative impacts to bald eagles as those described under Alternative 3, but Alternative 4 would result in an increasing trend (5 percent) in riparian woodland/forested wetland habitat, resulting in long-term beneficial impacts. When combined with other past, present, and reasonably foreseeable future actions, Alternative 4 would result in adverse and beneficial cumulative impacts. The implementation of Alternative 4 would provide a negligible contribution to overall cumulative impacts to bald eagles.

Alternative 5 would result in nearly identical adverse and beneficial cumulative impacts to bald eagles as those described under Alternative 3, based on EQ account results. Like Alternative 3, Alternative 5 would result in a slight increasing trend (9 percent) in riparian woodland/forested wetland habitat. When combined with other past, present, and reasonably foreseeable future actions, Alternative 5 would result in adverse and beneficial cumulative impacts. The implementation of Alternative 5 would provide a negligible contribution to overall cumulative impacts to bald eagles.

Alternative 6 would result in nearly identical adverse and beneficial cumulative impacts to bald eagles as those described under Alternative 4, resulting in an increasing trend (5 percent) in riparian woodland/forested wetland habitat. When combined with other past, present, and

reasonably foreseeable future actions, Alternative 6 would result in adverse and beneficial cumulative impacts largely based on changes in habitat availability, temporary habitat disturbances, land acquisition, and habitat creation and management. The implementation of Alternative 6 would provide a negligible contribution to overall cumulative impacts to bald eagles.

Northern Long-Eared Bat

Past and present actions that have adversely impacted the northern long-eared bat include any actions which may have resulted in the loss of roosting or nesting trees along riparian corridors in the Missouri River basin. These actions include floodplain development, transportation and utility corridor development, construction of the mainstem reservoir system, and bank stabilization and navigation projects. Operation and maintenance of the mainstem reservoir system and bank stabilization projects may temporarily impact this species due to noise and visual disturbances. These impacts are expected to continue into the future and any additional impacts as a result of these actions are expected to be negligible.

Reasonably foreseeable future actions which may adversely impact northern long-eared bats include future transportation and utility corridor development and conversion of habitat for agriculture and other land uses. These ongoing actions may result in loss, degradation, or fragmentation of riparian habitat. However, this would only occur if these actions result in the removal of mature riparian forest stands. Impacts of these reasonably foreseeable future actions would depend on the timing and location of specific actions, but are expected to be negligible.

Past, present, and reasonably foreseeable future projects and actions that create, develop, and/or manage habitat have provided or may provide beneficial impacts to northern long-eared bats. These actions include USFWS National Wildlife Refuge System Lands Management, USFWS Partners for Fish and Wildlife Program, NRCS Easement Programs, NRCS Technical and Financial Assistance Programs, EPA Section 319 Non-Point Source Grant Program, and Tribal programs and actions. The actions and programs are expected to have long-term beneficial impacts to northern long-eared bats.

When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts associated with Alternative 1 would be both beneficial and adverse. Adverse impacts would occur from any action that resulted in the disturbance or removal of mature trees. Beneficial impacts would occur as a result of land acquisition and habitat creation and management. The implementation of Alternative 1 would provide a negligible contribution to overall cumulative impacts to northern long-eared bats.

Under Alternatives 2–6 cumulative impacts from other past, present, and reasonably foreseeable future actions would be the same as described for Alternative 1. Alternative 2 would result in similar adverse impacts to northern long-eared bats as those described under Alternative 1, but Alternative 2 would result in an increasing trend (1 percent) in both riparian woodland/forested wetland and forest habitat in the upper and (21 percent) in the lower river, resulting in long-term beneficial impacts. When combined with other past, present, and reasonably foreseeable future actions, Alternative 2 would result in adverse and beneficial cumulative impacts largely based on changes in habitat availability, temporary habitat disturbances, land acquisition, and habitat creation and management. The implementation of Alternative 2 would provide a negligible contribution to overall cumulative impacts to northern long-eared bats.

Alternative 3 would result in similar adverse impacts to northern long-eared bats as those described under Alternative 2, but Alternative 3 would result in a downward trend (−4 percent) in riparian woodland/forested wetland and forest habitat in the upper river and a positive increasing trend (10 percent) in the lower river, resulting in long-term negligible adverse and small beneficial impacts. When combined with other past, present, and reasonably foreseeable future actions, Alternative 3 would result in adverse and beneficial cumulative impacts. The implementation of Alternative 3 would provide a negligible contribution to overall cumulative impacts to northern long-eared bats.

Alternative 4 would result in similar adverse cumulative impacts to northern long-eared bats as those described under Alternative 3, but Alternative 4 would result in no change (0 percent) in riparian woodland/forested wetland and forest habitat in the upper river and a positive increasing trend (14 percent) in the lower river, resulting in long-term negligible adverse and small beneficial impacts. When combined with other past, present, and reasonably foreseeable future actions, Alternative 4 would result in adverse and beneficial cumulative impacts. The implementation of Alternative 4 would provide a negligible contribution to overall cumulative impacts to northern long-eared bats.

Alternative 5 would result in nearly identical adverse and beneficial cumulative impacts to northern long-eared bats as those described under Alternative 3, resulting in a downward trend (−4 percent) in riparian woodland/forested wetland and forest habitat in the upper and a positive increasing trend (9 percent) in the lower river, based on EQ account results. When combined with other past, present, and reasonably foreseeable future actions, Alternative 5 would result in adverse and beneficial cumulative impacts and would provide a negligible contribution to overall cumulative impacts to northern long-eared bats.

Alternative 6 would result in similar adverse cumulative impacts to northern long-eared bats as those described under Alternative 3, but Alternative 6 would result in a negligible downward trend (−9 percent) in riparian woodland/forested wetland and forest habitat in the upper river and a positive increasing trend (6 percent) in the lower river, resulting in long-term negligible adverse and small beneficial impacts. When combined with other past, present, and reasonably foreseeable future actions, Alternative 6 would result in adverse and beneficial cumulative impacts largely based on changes in habitat availability, temporary habitat disturbances, land acquisition, and habitat creation and management. The implementation of Alternative 6 would provide a negligible contribution to overall cumulative impacts to northern long-eared bats.

Indiana Bat

Past, present, and reasonably foreseeable future actions that have caused or may cause adverse or beneficial impacts to the Indiana bat are the same as those described above for the northern long-eared bat. However, only those actions that occur in the lower Missouri River basin in the state of Missouri would impact Indiana bats because the upper basin and the states above Missouri in the lower basin are outside the geographic range of this species.

When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts associated with Alternative 1 would be both beneficial and adverse. Adverse impacts would occur from any action that resulted in the disturbance or removal of mature trees within the lower Missouri River basin in the state of Missouri. Beneficial impacts would occur as a result of land acquisition and habitat creation and management. The implementation of Alternative 1 would provide a negligible contribution to overall cumulative impacts to Indiana bats.

Cumulative impacts for Alternatives 2–6 from other past, present, and reasonably foreseeable future actions would be the same as described for Alternative 1. Alternative 2 would result in similar adverse impacts to Indiana bats as those described under Alternative 1, but Alternative 2 would result in an increasing trend (21 percent) in both riparian woodland/forested wetland and forest habitat in the lower river basin, resulting in long-term beneficial impacts. When combined with other past, present, and reasonably foreseeable future actions, Alternative 2 would result in adverse and beneficial cumulative impacts largely based on changes in habitat availability, temporary habitat disturbances, land acquisition, and habitat creation and management. The implementation of Alternative 2 would provide a negligible contribution to overall cumulative impacts to Indiana bats.

Alternative 3 would result in similar adverse impacts to Indiana bats as those described under Alternative 1, but Alternative 3 would result in an increasing trend (10 percent) in both riparian woodland/forested wetland and forest habitat in the lower river, resulting in long-term beneficial impacts. When combined with other past, present, and reasonably foreseeable future actions, Alternative 3 would result in adverse and beneficial cumulative impacts largely based on changes in habitat availability, temporary habitat disturbances, land acquisition, and habitat creation and management within the lower Missouri River basin. The implementation of Alternative 3 would provide a negligible contribution to overall cumulative impacts to Indiana bats.

Under Alternative 4 cumulative actions would result in similar adverse impacts to northern long-eared bats as those described under Alternative 3, but Alternative 4 would result in an increasing trend (14 percent) in riparian woodland/forested wetland and forest habitat in the lower river, resulting in long-term beneficial impacts. When combined with other past, present, and reasonably foreseeable future actions, Alternative 4 would result in adverse and beneficial cumulative impacts within the lower Missouri River basin and would provide a negligible contribution to overall cumulative impacts to Indiana bats.

Alternative 5 would result in nearly identical adverse and beneficial cumulative impacts to Indiana bats as those described under Alternative 3, resulting in a positive increasing trend (9 percent) in riparian woodland/forested wetland and forest habitat in the lower river based on EQ account results. When combined with other past, present, and reasonably foreseeable future actions, Alternative 5 would result in adverse and beneficial cumulative impacts within the lower Missouri River basin and would provide a negligible contribution to overall cumulative impacts to Indiana bats.

Alternative 6 would result in similar adverse cumulative impacts to Indiana bats as those described under Alternative 3, but Alternative 6 would result in an increasing trend (6 percent) in riparian woodland/forested wetland and forest habitat in the lower river, resulting in a long-term small beneficial impact. When combined with other past, present, and reasonably foreseeable future actions, Alternative 6 would result in adverse and beneficial cumulative impacts and would provide a negligible contribution to overall cumulative impacts to Indiana bats.

Western Prairie Fringed Orchid

Past and present actions that have adversely impacted the western prairie fringed orchid include any actions which may have resulted in loss, degradation, or fragmentation of prairie habitat along the Missouri River basin. These actions include floodplain development (conversion of habitat) for agriculture and other land uses, utility corridor development. Construction or maintenance activities which traverse high quality undisturbed prairie habitat

with heavy equipment may crush individual plants or damage habitat. These actions include construction, operation and management of the mainstem reservoir system, bank stabilization and navigation projects. These impacts are expected to continue into the future and any additional impacts as a result of these actions are expected to be negligible.

Reasonably foreseeable future actions which may adversely impact the western prairie fringed orchid include future transportation and utility corridor development and conversion of habitat for agriculture and other land uses. These ongoing actions may result in the destruction of individual plants, and loss, degradation, or fragmentation of prairie habitat. Impacts of these reasonably foreseeable future actions would depend on the timing and location of specific actions. These actions are expected to result in a long-term small adverse impact to the western prairie fringed orchid.

Past, present, and reasonably foreseeable future projects and actions that create, develop, and/or manage high quality prairie habitat have provided or may provide beneficial impacts to the western prairie fringed orchid. These actions include the USFWS National Wildlife Refuge System Lands Management, USFWS Partners for Fish and Wildlife Program, NRCS Easement Programs, NRCS Technical and Financial Assistance Programs, EPA Section 319 Non-Point Source Grant Program, and Tribal programs and actions. The actions and programs are expected to have long-term beneficial impacts to the western prairie fringed orchid.

When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts associated with Alternative 1 would be both beneficial and adverse. Adverse impacts would occur if plants are crushed by construction equipment traversing the area to access sites during construction or maintenance activities. Implementation of Alternative 1 is expected to provide a negligible contribution to overall cumulative impacts to the western prairie fringed orchid.

Under Alternatives 2–6 cumulative impacts from other past, present, and reasonably foreseeable future actions would be the same as described for Alternative 1. Alternative 2 would result in a direct, long-term, small adverse impact to the western prairie fringed orchid due to a downward trend (−15 percent) in upland grassland habitat. When combined with other past, present, and reasonably foreseeable future actions, Alternative 2 would result in adverse and beneficial cumulative impacts largely based on changes in habitat availability, temporary habitat disturbances, land acquisition, and habitat creation and management. The implementation of Alternative 2 would provide a small contribution to overall cumulative impacts to the western prairie fringed orchid.

Alternative 3 would result in a direct, long-term, small adverse impact to the western prairie fringed orchid due to a downward trend (−9 percent) in upland grassland habitat. When combined with other past, present, and reasonably foreseeable future actions, Alternative 3 would result in adverse and beneficial cumulative impacts and would provide a small contribution to overall cumulative impacts to the western prairie fringed orchid.

Alternative 4 would not result in adverse impacts to the western prairie fringed orchid. When combined with other past, present, and reasonably foreseeable future actions, Alternative 4 would result in adverse and beneficial cumulative largely based on changes in habitat availability, temporary habitat disturbances, land acquisition, and habitat creation and management. The implementation of Alternative 4 would provide a negligible contribution to overall cumulative impacts to the western prairie fringed orchid.

Alternative 5 would result in a direct, long-term, small adverse impact to the western prairie fringed orchid due to a downward trend (−7 percent) in upland grassland habitat. When combined with other past, present, and reasonably foreseeable future actions, Alternative 5 would result in adverse and beneficial cumulative impacts largely based on changes in habitat availability, temporary habitat disturbances, land acquisition, and habitat creation and management. The implementation of Alternative 5 would provide a small contribution to overall cumulative impacts to the western prairie fringed orchid.

Alternative 6 would result in a direct, long-term, small adverse impact to the western prairie fringed orchid due to a downward trend (−5 percent) in upland grassland habitat. When combined with other past, present, and reasonably foreseeable future actions, Alternative 6 would result in adverse and beneficial cumulative impacts and would provide a small contribution to overall cumulative impacts to the western prairie fringed orchid.

Other Special-Status Species

Cumulative impacts to other special-status species would be commensurate with impacts to the habitats in which they occur and would depend on specific timing and location of each management action. Habitat preferences and locations of special-status species are shown in Appendix E. Aquatic species would likely be impacted the most. In general, special-status species which have habitat requirements similar to those of pallid sturgeon could benefit in the long term, although some species would be temporarily displaced during construction activities resulting in direct or indirect, temporary, adverse impacts. Species which are not associated with these habitats would not likely be impacted. Cumulative impacts to other special-status species would be similar to those described for fish and wildlife habitat.

When combined with other past, present, and reasonably foreseeable future actions, Alternative 1 would result in adverse and beneficial cumulative impacts largely based on changes in habitat conversion and availability. In general, implementation of Alternative 1 would provide a negligible contribution to overall cumulative impacts to other special-status species.

Under Alternatives 2–6, cumulative impacts from other past, present, and reasonably foreseeable future actions would be the same as described for Alternative 1. Aquatic species would likely be impacted the most. Cumulative impacts to other special-status species would be similar to those described under Section 3.5, Fish and Wildlife Habitat. Alternatives 2–6 would result in adverse and beneficial cumulative impacts largely based on changes in habitat availability, temporary habitat disturbances, land acquisition, and habitat creation and management. The implementation of Alternatives 2–6 would provide a negligible contribution to overall cumulative impacts to other special-status species.

3.7 Water Quality

3.7.1 Affected Environment

The chemical and physical properties of Missouri River water influence the presence, growth, and survival of aquatic species and affect human uses of the river including water supply, wastewater, irrigation, power generation, and recreation. Water quality and sources of pollution can vary greatly along the length of the 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. Although states along the Missouri River do not have numeric water quality standards for nutrients, excessive nutrients can influence water quality locally as well as downstream including in the Gulf of Mexico where hypoxia is a concern. Studies have shown that nutrients from the Missouri River basin would not increase the hypoxic zone and that ESH and SWH construction would not be problematic for the Missouri River (Gosch et al. 2013; National Research Council 2011; USACE 2013). Elutriate testing assesses excavated or dredged sediment/soil for metals/metalloids at all sites of ESH and SWH construction; elutriate testing at specific sites has revealed that metal/metalloid concentrations from excavated or dredged material is less than existing water quality criteria and not considered problematic (USACE 2013). Mobilized organic matter could contain trihalomethane precursors, which can form carcinogens when in contact with chlorine; however, a study noted that although trihalomethanes can increase on a seasonal basis, increased levels of trihalomethane were not associated with dredging activities for ESH construction (USACE 2009).

This section provides a description of the existing conditions of water quality of the Missouri River mainstem reservoirs, inter-reservoir reaches, and the lower river below Gavins Point Dam. Water quality issues and applicable water quality standards and regulations related to the operation of thermal power and wastewater facilities are discussed in Section 3.17, Thermal Power, and Section 3.19, Wastewater Facilities.

3.7.1.1 Missouri River Mainstem Reservoirs

General water quality concerns in the Missouri River mainstem reservoirs include eutrophication and sedimentation, depletion of dissolved oxygen in the hypolimnion, shoreline erosion, and bioaccumulation of contaminants in aquatic organisms. The deeper mainstem reservoirs have issues with seasonally depleted hypolimnetic dissolved oxygen (i.e., hypoxic) and hypolimnetic discharges (cold water from the bottom layer of the reservoir that can have low dissolved oxygen concentrations) especially when lake pool levels are low.

Turbidity levels are typically higher at the upper end of the reservoirs due to the inflow of suspended material from the mainstem Missouri River. However, turbidity quickly decreases as

the river enters the reservoirs. The water columns of the reservoirs are relatively free of sediment and turbidity because sediment and particulate nutrients drop out of suspension and settle to the bottom of the reservoir behind the dam. Water temperatures can vary with depth as thermal stratification takes place with warmer water on the top and colder water on the bottom. In general, lake water temperatures are higher when the lake pool elevation is low and/or when the ambient air temperature is higher. Deeper reservoirs will experience thermal stratification of their impoundments in the summer. As air temperatures heat up in warmer months, an epilimnion (upper layer), metalimnion (middle layer or thermocline), and hypolimnion (bottom layer) can form and the waters at the upstream end of the reservoir warm up faster than those close to the dam (USACE 2016a). The cold hypolimnion can be as much as 10°C colder than the epilimnion (USACE 2010a). Winter stratification causes denser water (4°C) to settle to the bottom with colder less dense water (< 1°C) to rise above the slightly warmer water below (USACE 2010a). The water temperatures in most reservoirs vary both longitudinally (i.e., from the dam upstream to where the mainstem Missouri River enters the reservoir) and vertically (i.e., from the lake surface to the bottom), as well as seasonally. Surface waters in the upstream area of the reservoirs typically warm up sooner than areas close to the dams. Stratification takes place near the dams whereas the shallower upstream areas of the reservoirs usually do not stratify. Dissolved oxygen concentrations are affected by water temperature with warmer water holding less oxygen than colder water. Deeper areas of reservoirs areas show more pronounced vertical variations in temperature and dissolved oxygen compared to shallower areas (USACE 2016a). Where stratification occurs, dissolved oxygen concentrations decrease along the bottom of the reservoir and are degraded in the hypolimnion.

Although the same general conditions exist in all of the mainstem reservoirs, some display slightly varied specific conditions due to location or physical parameters. Lake Sharpe and Lewis and Clark Lake are shallower than the other reservoirs and stratification is sometimes limited and not well defined. Lake Sharpe and Lake Francis Case, that are closer to the adjacent upstream dam, are somewhat influenced by the dam releases that enter the lake headwaters. Additionally, some mainstem reservoirs are influenced by tributaries that deliver water with varying concentrations of sediment, nutrients, and other pollutants.

3.7.1.2 Inter-Reservoir River Reaches

The discharge from the dams is from the hypolimnion layer (i.e., bottom layer) of the stratified reservoir. In the spring and summer, withdrawing water from this layer results in cooler water temperatures downstream of the dams than would naturally occur. The temperature below dams can be cold for long periods. Differences in the water temperature of inflow and outflow reservoir water can range from 4°C to 10°C (Galat et al. 2005; USACE 2010a). During winter reservoir stratification, dams discharge hypolimnetic water into tailwater areas that is warmer by 1°C to 3°C than would naturally occur (USACE 2006a; USACE 2010a). Water temperature issues related to the operation of thermal power plants in the inter-reservoir reaches are discussed in Section 3.17, Thermal Power.

The water quality in the inter-reservoir river reaches is generally in compliance with water quality standards. Land use in the upper basin is primarily agriculture (livestock and cropland) and undeveloped open spaces with few urban areas or industrial uses (USGS 2001). Development and urbanization, which usually contribute the most nitrogen and phosphorus to the river, are not significant parts of the landscape in this part of the basin. Small municipal wastewater treatment systems associated with the existing riverside communities likely have modest water quality impacts. The presence of the dams influences sediment and turbidity, water temperature, and phosphorus concentrations. The mainstem Missouri River reservoirs act as a

sink for sediment and nutrients (USACE 2016a). The river reaches located between the reservoirs typically have very low sediment, turbidity, and particulate nutrients due to the capture of particulates behind the dams (Galat et al. 2001).

Fort Peck Dam to Lake Sakakawea

Temperature and Dissolved Oxygen: Hypolimnetic releases from Fort Peck Dam cause the river, from the tailwaters to approximately 70 miles downstream from the dam, to be characterized by cold, clear waters (Montana Fish, Wildlife, and Parks 2005). At Frazer, Montana, approximately 30 miles downstream from the dam, model simulations show that the average temperature in the period June to August was 13.2°C with a high of 17.3°C (USACE 2007c). Approximately 100 miles downstream from Garrison Dam the temperature is still low (15.6°C) (USFWS 2000). In general, water temperatures below Fork Peck Dam are higher when the lake pool elevation is low, dam discharges are lower, and when the ambient air temperature is higher (USACE 2007c; USACE 2016a). Water released from the Fort Peck Dam spillway is warmer than the tailwater released directly into the Missouri River (USACE 2007c). Simulations showed that spillway temperatures reach 17°C in late June and stay above 17°C until the end of September (USACE 2007c). Table 3-16 shows mean water temperature for May to September during the period from 2012 to 2014.

Table 3-16. Mean Monthly Water Temperature (°C) in the Inter-Reservoir Reaches (2012–2014)

Location	Water Temperature (°C)							
	January	April	May	June	July	August	Sept	October
Fort Peck Dam to Lake Sakakawea								
Powerplant Discharge	3.6	4.6	7.0	9.3	11.5	13.6	12.4	13.3
Williston, ND	-	8.1	16.0	21.4	23.4	19.4	16.0	8.1
Garrison Dam to Lake Oahe								
Powerplant Discharge	2.7	4.3	6.9	10.4	10.4	13.9	13.4	12.6
Bismarck, ND	4.7	11.4	16.1	17.4	17.6	16.1	10.3	4.7
Oahe Dam to Lake Sharpe								
Powerplant Discharge	4.8	4.6	10.9	14.2	17.1	21.1	18.3	13.2
Big Bend Dam to Lake Francis Case								
Powerplant Discharge	2.6	6.6	15.4	20.5	21.5	22.5	20.2	11.8
Fort Randall Dam to Lewis and Clark Lake								
Powerplant Discharge	1.6	3.0	2.8	5.0	9.8	17.0	20.0	24.6
Running Water, SD	0.8	2.53	-	8.0	15.4	20.1	23.9	24.4

Source: USACE 2016b

Recent measurements showed that water released from Fort Peck Lake is low in dissolved oxygen but that the levels do not fall below the minimum water quality standards (USACE

2012a). Table 3-17 shows mean dissolved oxygen concentrations for May to September during the period 2012 to 2014.

Table 3-17. Mean Monthly Dissolved Oxygen Concentrations (mg/L) in the Inter-Reservoir Reaches (2012–2014)

Location	Dissolved Oxygen (mg/L)							
	January	April	May	June	July	August	Sept	October
Fort Peck Dam to Lake Sakakawea								
Powerplant Discharge	12.6	12.2	11.5	9.9	8.2	6.8	6.2	8.3
Williston, ND	-	10.9	8.9	8.4	8.0	8.7	9.4	10.8
Garrison Dam to Lake Oahe								
Powerplant Discharge	13.1	12.1	11.7	10.5	8.9	7.3	6.6	9.4
Bismarck, ND	12.0	11.1	10.1	9.5	8.7	9.4	12.0	12.0
Oahe Dam to Lake Sharpe								
Powerplant Discharge	12.7	12.6	11.2	10.1	9.0	8.1	8.3	9.5
Big Bend Dam to Lake Francis Case								
Powerplant Discharge	13.4	11.8	10.0	8.4	7.2	6.7	8.0	10.0
Fort Randall Dam to Lewis and Clark Lake								
Powerplant Discharge	13.7	12.9	13.5	12.5	11.1	9.1	8.2	7.1
Running Water, SD	15.1	12.1	-	12.0	10.1	8.6	8.0	7.9

Source: USACE 2016b

Turbidity and Nutrients: Sediment, turbidity, and phosphorus concentrations downstream from Fort Peck Dam are much lower than upstream concentrations because most sediment and particulate phosphorus and nitrogen is trapped behind the dam and settles out in the reservoir (Ward and Stanford 1983; Schmulbach et al. 1992). However, compared to the reaches downstream from Oahe, Big Bend, and Fort Randall Dams, the reaches downstream from Fort Peck and Garrison Dams are less affected by sediment and phosphorus entrapment. Turbidity and phosphorus concentrations increase with greater distances downstream from the Fort Peck tailwaters as tributaries supply sediment, particulates, and nutrients (Galat et al. 2001). The Milk River inputs turbidity to the Missouri River but the mainstem does not fully recover its naturally turbid condition until the confluence of the Yellowstone River. Table 3-18 shows the median and range of turbidity and nutrient concentrations for the Fort Peck Dam powerplant discharge and Williston, North Dakota during the period 2010 to 2014. The table shows that approximately 200 miles downstream at Williston, the concentrations have increased (USACE 2016a). High nutrient flux rates in the Fort Peck Dam powerplant discharge were associated with higher discharges from the dam (USACE 2016a). Higher nutrient flux rates at Williston were attributed to higher nonpoint source runoff at certain times (USACE 2016a).

Table 3-18. Turbidity and Nutrients in the Inter-Reservoir Reaches (2010–2014)

Reservoir Location	Turbidity (in Nephelometric Turbidity Units [NTU])		Nitrate-Nitrite Nitrogen (mg/L)		Total Nitrogen (mg/L)		Total Phosphorus (mg/L)	
	Range	Median	Range	Median	Range	Median	Range	Median
Fort Peck Dam to Lake Sakakawea								
Powerplant Discharge	n.d.–30	—	n.d.–17	n.d.	—	—	n.d.–17	n.d.
Williston, ND	3–1,447	114	n.d.–0.39	0.06	0.3–2.5	0.6	0.06–1.39	0.16
Garrison Dam to Lake Oahe								
Powerplant Discharge	n.d.–45	3	n.d.–0.2	0.07	n.d.–1.3	0.4	n.d.–0.06	n.d.
Bismarck, ND	1–141	6	n.d.–0.40	0.06	n.d.–1.4	0.4	n.d.–0.85	0.03
Oahe Dam to Lake Sharpe								
Powerplant Discharge	1–24	14	n.d.–0.20	0.07	n.d.–1.3	0.4	n.d.–0.10	0.02
Big Bend Dam to Lake Francis Case								
Powerplant Discharge	n.d.–708	4	n.d.–1.0	0.08	n.d.–3.38	0.47	n.d.–0.06	0.03
Fort Randall Dam to Lewis and Clark Lake								
Powerplant Discharge	n.d.–22	2	n.d.–0.42	0.08	0.22–1.01	0.49	n.d.–0.08	0.02
Tailwaters	n.d.–21	3	n.d.–0.40	0.08	n.d.–2.36	0.46	n.d.–0.09	0.02
Verdel, NE	n.d.–89	4	n.d.–0.40	0.06	0.05–1.18	0.46	n.d.–0.11	0.02
Running Water, SD	n.d.–389	10	n.d.–1.00	0.10	n.d.–2.25	0.51	n.d.–0.33	0.51

Source: USACE 2016a

n.d. – Not detected

Other Pollutants: Testing of sediments within the reach from the Fort Peck Dam to the Yellowstone River resulted in the identification of samples with lethal and growth inhibiting toxicity (Haring et al. 2010). A pesticide scan of water released from the Fort Peck Dam, sampled from 2010 to 2014, did not detect any of 29 pesticides (USACE 2016a). Monitoring of water quality near Williston, North Dakota, indicated high levels of total aluminum, total iron, and total manganese; however, it was noted that the higher concentrations are due to the local geology and are not considered water quality problems (USACE 2016a). Arsenic, cadmium, chromium, copper, and nickel were also found but in lower concentrations (USACE 2016a). Monitoring of water released from the Fort Peck Dam powerplant showed no water quality exceedances except for cadmium in one sample (USACE 2016a).

Garrison Dam to Lake Oahe

Temperature and Dissolved Oxygen: The tailwater discharged from the Garrison Dam powerhouse into the Missouri River is withdrawn from Lake Sakakawea at an intake very close to the bottom of the reservoir. The position of this intake influences the water temperature and

dissolved oxygen content of the water in the Garrison Dam to Lake Oahe reach. The river reach downstream of Garrison Dam is periodically oxygen deficient due to the cold hypolimnetic water discharged from the dam; however, the lower dissolved oxygen conditions dissipate quickly due to mixing as the flow moves farther downstream (USACE 2006b; USACE 2010b). Dissolved oxygen concentrations are high and relatively stable during the winter months, but decline through the spring and summer as oxygen degrades in the stratified reservoir, and finally increase again in the fall (USACE 2016a). Table 3-16 and Table 3-17 show temperature and dissolved oxygen values for the river reach downstream of Garrison Dam measured over the period from 2012 to 2014.

Turbidity and Nutrients: Table 3-18 shows the median and range of turbidity and nutrient concentrations for the Garrison Dam powerplant discharge and Bismarck, North Dakota during the period 2010 to 2014. The table shows that approximately 75 miles downstream at Bismarck, the concentrations have increased slightly (USACE 2016a). High nutrient flux rates in the powerplant discharge were associated with higher discharges from Garrison Dam (USACE 2016a). Higher nutrient flux rates at Bismarck were attributed to higher nonpoint source runoff at certain times (USACE 2016a).

Other Pollutants: The inter-reservoir reach from Garrison Dam to Lake Oahe is influenced by urban and industrial contamination (USACE 2006b). Testing of sediments within some reaches, particularly Garrison Dam to Bismarck, resulted in the identification of samples with lethal and growth inhibition toxicity (Haring et al. 2010). Annual testing of metals from 2010 to 2014 showed no exceedances of water quality standards (USACE 2016a). A pesticide scan of water released from the Garrison Dam and from Bismarck, sampled from 2010 to 2014, did not detect any of 29 pesticides (USACE 2016a). A fish consumption advisory exists for the Missouri River reach between Garrison Dam and Lake Oahe due to methylmercury (NDDH 2015).

Oahe Dam to Lake Sharpe

The river reach between Oahe Dam and the start of Lake Sharpe is just a few miles in length. Water quality characteristics of the Oahe Dam releases represent the short river reach upstream of Lake Sharpe.

Temperature and Dissolved Oxygen: Water temperatures of Oahe Dam powerhouse releases showed a range of 13.5°C to 21°C in July and a range of 2.9°C to 5.9°C in January (USACE 2016b). Dissolved oxygen in the powerhouse releases ranged from 8.2 mg/L to 9.9 mg/L in July and 12.0 mg/L to 13.4 mg/L in January (USACE 2016b). Table 3-16 and Table 3-17 show temperature and dissolved oxygen values for the river reach downstream of Oahe Dam.

Turbidity and Nutrients: High nutrient flux rates in the powerplant discharge were associated with higher discharges from Oahe Dam (USACE 2016a). Table 3-18 shows the median and range of turbidity and nutrient concentrations for the Oahe Dam powerplant discharge during the period 2010 to 2014.

Other Pollutants: The inter-reservoir reach from Oahe Dam to Lake Sharpe is influenced by urban and industrial contamination (USACE 2006b). A pesticide scan of water released from Oahe Dam, sampled from 2010 to 2014, did not detect any of 29 pesticides (USACE 2016a).

Big Bend Dam to Lake Francis Case

There is no inter-reservoir river reach located between Big Bend Dam and the upstream end of Lake Francis Case. The water quality characteristics of the Big Bend Dam releases are discussed in this section and represent the inflow to Lake Francis Case.

Temperature and Dissolved Oxygen: Water discharged from Big Bend Dam to Lake Francis Case shows seasonal variations in water temperature and dissolved oxygen. Although the Big Bend Dam discharges are withdrawn from the bottom of the reservoir, the reservoir stratification is limited as is the formation of a cold hypolimnion. In the summer, water temperatures are above 18°C. Table 3-16 and Table 3-17 show temperature and dissolved oxygen values for the river reach downstream of Big Bend Dam.

Turbidity and Nutrients: High nutrient flux rates in the powerplant discharge were associated with higher discharges from Big Bend Dam (USACE 2016a). Table 3-18 shows the median and range of turbidity and nutrient concentrations for the Big Bend Dam powerplant discharge during the period 2010 to 2014.

Other Pollutants: The inter-reservoir reach from Big Bend Dam to Lake Francis Case is influenced by urban and industrial contamination (USACE 2006b). Additionally, agricultural runoff and the pesticides atrazine and metribuzin have been detected (USACE 2006b). A pesticide scan of water released from Big Bend Dam, sampled from 2010 to 2014, did not detect any of 29 pesticides (USACE 2016a). Arsenic exceeded human health criterion on each of four monitoring dates from 2010 to 2014; the highest arsenic concentration was 2 µg/L (USACE 2016a).

Fort Randall Dam to Lewis and Clark Lake

Temperature and Dissolved Oxygen: Water temperatures in this reach are stable in winter, early spring, and fall but show variability throughout late spring and summer. Dissolved oxygen concentrations are typically higher in winter, decline somewhat in spring and summer, and increase again in the fall (USACE 2016a). This reach is periodically oxygen deficient with concentrations below 5 mg/L due to the cold hypolimnetic cold water discharged from the dam; however, the low dissolved oxygen conditions dissipate quickly due to mixing as the flow moves farther downstream (USACE 2006b; USACE 2010b). Table 3-16 and Table 3-17 show temperature and dissolved oxygen values for the river reach downstream of Fort Randall Dam.

Turbidity and Nutrients: High nutrient flux rates in the Fort Randall Dam powerplant discharge were associated with higher discharges from the dam (USACE 2016a). However, higher nutrient flux rates at Running Water were attributed to higher nonpoint source runoff at certain times (USACE 2016a). Table 3-18 shows the median and range of turbidity and nutrient concentrations for the Fort Randall Dam powerplant discharge, the tailwaters, and two downstream sites during the period 2010 to 2014.

Other Pollutants: Testing of sediments within some reaches, particularly Fort Randall Dam to the Niobrara River, resulted in the identification of samples with lethal and growth inhibition toxicity (Haring et al. 2010). A site-specific study found elevated mean levels of mercury in the sediments in this reach (Pracheil et al. 2010). Additionally, potential problems for the mainstem reaches downstream of Fort Randall Dam include agricultural runoff (USACE 2006b). A pesticide scan of water released from Big Bend Dam, sampled from 2010 to 2014, did not

detect any of 29 pesticides (USACE 2016a). Arsenic was found in samples; the highest measured concentration was 3 µg/L (USACE 2016a).

3.7.1.3 Lower Mainstem

There are more urban areas and communities downstream of Gavins Point Dam that have a greater influence on Missouri River water quality than in the upstream reaches. The lower reaches of the Missouri River are especially influenced by urban and industrial contamination from metropolitan areas such as Sioux City, Omaha, St. Joseph, and Kansas City. Urban contributions of pollution, including stormwater discharge and runoff and wastewater treatment plant discharge are higher than in the upper mainstem reaches.

Temperature and Dissolved Oxygen: There is limited to no stratification in Lewis and Clark Lake, therefore, the dam releases are not hypolimnetic. Temperature and dissolved oxygen are influenced by ambient conditions. Dissolved oxygen concentrations are lower in the warmer months due to the decrease in dissolved oxygen solubility with warm water stratification, and if stratification becomes established, due to hypolimnetic oxygen degradation (USACE 2016a). Organic waste discharges and increased turbidity to the mainstem may create local zones of high biological oxygen demand that will exhibit temporary dissolved oxygen minima in the lower river reaches. Table 3-19 and Table 3-20 show average monthly temperature and dissolved oxygen values for the Missouri River downstream of Gavins Point Dam.

Table 3-19. Mean Monthly Water Temperature (°C) in the Lower Missouri River

Year	Water Temperature (°C)							
	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct
2012	16.0	16.2	21.7	26.2	30.3	26.4	21.0	15.1
2013	4.2	9.9	16.6	21.6	26.2	25.1	27.6	16.6
2014	5.2	10.6	17.2	21.7	24.0	26.2	19.0	13.6

Source: USACE 2016c

Table 3-20. Mean Monthly Dissolved Oxygen Concentrations (mg/L) in the Lower Missouri River

Year	Dissolved Oxygen (mg/L)							
	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct
2012	8.4	6.6	8.2	7.6	8.6	7.9	8.8	9.5
2013	11.5	10.4	8.2	7.4	7.3	7.4	7.7	9.2
2014	12.8	10.7	8.3	3.7	6.1	6.8	6.5	7.7

Source: USACE 2016c

Turbidity and Nutrients: Suspended sediment concentrations are variable along the reach but tend to increase in the downstream direction (USACE 2015a). Tailwater released from Gavins Point Dam has very low turbidity with a median of 10 NTU (USACE 2016a). Bank stabilization structures reduce the input of sediment to the river through the processes of bank erosion or floodplain connectivity. The James and Vermillion rivers add turbidity, but the lower Missouri River is still highly sediment depleted and downcutting. Additional sediment is added by tributaries farther downstream, thereby somewhat offsetting the sediment reducing effects of the

upstream dams (Poulton et al. 2005). Sediment concentrations range from 7.3 Mt/year at Sioux City, IA to 58 Mt/year at Hermann, Missouri. In general, the relative sediment inputs contributed by these tributaries to the lower mainstem reaches are much larger than inputs from upper mainstem tributaries (NRC 2010). Table 3-21 shows that turbidity generally increases with distance along the lower river.

Table 3-21. Turbidity in the Lower Missouri River (2012–2014)

Location	Median Turbidity (NTU)		
	2012	2013	2014
Ponca, NE	—	25.0	22.3
Decatur, NE	—	35.9	32.0
Omaha, NE	—	61.7	39.9
Nebraska City, NE	—	61.7	42.2
Rulo, NE	—	63.0	12.7
Atchison, KS	46.2	68.6	105.0
Kansas City, MO	49.6	90.1	99.5
Waverly, MO	70.4	135.4	87.3
Glasgow, MO	107.6	111.6	264.9
Marion, MO	112.8	99.5	164.2
Hermann, MO	97.3	67.7	135.6
Weldon, MO	96.1	69.8	133.4

Source: USACE 2016c

Higher discharges from Gavins Point Dam are associated with higher nutrients in the dam discharge (USACE 2016a). Nitrogen and phosphorus concentrations are much greater along the lower river due to point and nonpoint source nutrient inputs especially from urban areas and agriculture. Nutrient concentrations are variable along the reach but tend to increase in the downstream direction (USACE 2015a). Nitrate-nitrogen amounts are much greater than those observed in the inter-reservoir and reservoir reaches (Blevins and Fairchild 2001; Havel et al. 2009). An increase in nitrate-nitrogen concentrations with distance downstream from Gavins Point Dam is caused by inflows from several highly agricultural watersheds between Yankton, SD and St. Joseph, Missouri (Blevins et al. 2014). The urban areas of Sioux City and Omaha also contribute to the high loads (USACE 2016a). Below Sioux City, tributaries entering the Missouri River add nitrogen and phosphorous, nearly doubling the amount of these nutrients, especially close to Omaha (Blevins and Fairchild 2001; Havel et al. 2009). Table 3-22 shows nutrient concentrations measured in 2012 through 2014 at sites along the lower reaches of the Missouri River.

Table 3-22. Nutrient Concentrations in the Lower Missouri River (2012–2014)

Location	Median Nitrate-Nitrite Nitrogen (mg/L)			Median Total Phosphorus (mg/L)		
	2012	2013	2014	2012	2013	2014
Ponca, NE	—	0.07	0.06	—	0.05	0.05
Decatur, NE	—	0.55	0.20	—	0.11	0.10
Omaha, NE	—	0.78	0.51	—	0.18	0.11
Nebraska City, NE	—	0.85	0.82	—	0.24	0.23
Rulo, NE	—	0.96	0.22	—	0.24	1.38
Atchison, KS	1.01	1.10	1.50	0.23	0.20	0.60
Kansas City, MO	0.87	1.40	1.50	0.32	0.23	0.51
Waverly, MO	0.94	1.40	1.40	0.29	0.31	0.49
Glasgow, MO	1.00	1.40	1.02	0.32	0.32	0.83
Marion, MO	0.80	1.55	1.00	0.29	0.29	0.69
Hermann, MO	0.74	1.30	1.00	0.28	0.24	0.56
Weldon, MO	0.84	0.71	1.02	0.26	0.25	0.72

Source: USACE 2016c

Other Pollutants: Arsenic was found in samples of water discharged from Gavins Point Dam; the highest measured concentration was 4 µg/L (USACE 2016a).Concentrations of *Escherichia coli* (*E. coli*) bacteria, which exceed state criteria, have been found in the Missouri River in Nebraska and Missouri (MODNR 2016; NEDEQ 2016). Sediments along the lower river have resulted in instances of lethal and chronic toxicity (Haring et al. 2010; Poulton et al. 2005). Bioaccumulative legacy contaminants such as chlordane and polychlorinated biphenyls (PCBs) are found in some river sediments (MODNR 2016; NEDEQ 2016). Sites immediately downstream of Kansas City have high levels of contaminants such as pesticides, PCBs, polycyclic aromatic hydrocarbons, metals, or polybrominated diphenyl ethers, although there is a reduction in the effects of this pollution further downstream (Echols et al. 2008; Poulton et al. 2005). The pesticides acetochlor, atrazine, and prometon were present in samples collected at Decatur, but not at levels that exceeded water quality criteria (USACE 2016a). The pesticides acetochlor, atrazine, bromacil, chlorpyrifos, ethalfluralin, and metolachlor were present in samples collected at Omaha; however, only chlorpyrifos was present at levels that exceeded water quality criteria (USACE 2016a). At Nebraska City and Rulo, the pesticides acetochlor, atrazine, and metolachlor were present but not at levels that exceeded water quality criteria (USACE 2016a). Missouri River tributaries in the lower river contribute *E. coli*, selenium, atrazine, dieldrin, PCBs, mercury, nutrients, chlordane, and sediment, potentially influencing water quality.

3.7.1.4 Water Quality on Tribal Lands

The waterways on most Tribal lands are not protected by water quality standards under the Clean Water Act (CWA). Of the 29 Tribes within or around the Missouri River basin, only the Assiniboine and Sioux Tribes of the Fort Peck Indian Reservation currently have their own water quality standards approved by the EPA. Many Tribes have expressed concern about the quality of Missouri River water, especially for water supply, irrigation, and recreation, and that in general they have little or no control over the quality of the water on their land. Issues include

sedimentation and water contamination related to wastewater effluent, chemicals from irrigated fields and lawns, oil and gas industry pollutants, and residential sewage disposal. The Cheyenne River Sioux Tribe issued a fish consumption advisory for Lake Oahe (USACE 2016a).

3.7.2 Environmental Consequences

The water quality environmental consequences analysis assesses the anticipated changes to Missouri River water quality conditions in riverine and reservoir reaches for each alternative. Water quality impacts related to wastewater or thermal power are discussed in Section 3.17, Thermal Power and Section 3.19, Wastewater Facilities.

3.7.2.1 Impacts Assessment Methodology

Identified water quality parameters of interest to this assessment include water temperature, dissolved oxygen, sediment and turbidity, nitrogen and phosphorus, 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. The impacts assessment was qualitative and based on available data, published literature, and unpublished agency studies and reports on the water quality of the Missouri River. The impacts analysis assessed impacts based on potential violation/attainment of State water quality standards developed pursuant to the CWA. Water quality criteria promulgated by the states under the CWA emphasize water clarity as an important indicator, and high levels of suspended sediment and turbidity are considered characteristics of poor water quality and an adverse impact. However, suspended sediment and turbidity levels were naturally high in the Missouri River prior to the construction of the mainstem dams and these conditions could have a positive effect on native aquatic species such as pallid sturgeon. This benefit is at odds with the state water quality standards and adverse impacts to water quality from increased concentrations of suspended sediment and turbidity. The analysis assumed that spawning habitat would require re-engineering of existing channel morphology because the characteristics of pallid sturgeon spawning habitat are not currently well known. The No Action Alternative is considered the baseline against which the other alternatives are measured. Under the No Action Alternative, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, the No Action Alternative does 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 area of analysis includes the mainstem Missouri River from Fort Peck Dam to the confluence with the Mississippi River. The analysis includes reservoirs and inter-reservoir reaches along the river.

3.7.2.2 Summary of Environmental Consequences

The actions common to all of the alternatives considered in this MRRMP-EIS, as well as the actions specific to each alternative, would likely have negligible to large, adverse impacts on water quality and small to large, beneficial impacts. Table 3-23 summarizes the impacts of each alternative to water quality.

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.

Table 3-23. Environmental Consequences for Water Quality

Alternative	Impacts to Water Quality
Actions Common to All Plan Alternatives	• Vegetation management practices would result in temporary, negligible, adverse impacts on water quality from herbicide application and the introduction of pollutants into the water. • Predator management and human restriction measures would have no impact on water quality.
Alternative 1	• There would be temporary, negligible, adverse impacts from increased nutrients, pollutants, water temperatures, and lower dissolved oxygen concentrations as well as temporary, small, adverse impacts from increased sediment and turbidity. • Long-term, negligible, adverse impacts could result from localized areas of increased water temperatures and lower dissolved oxygen levels, and long-term, negligible, beneficial impacts from reduced nutrients and pollutants. • Overall, these impacts would influence localized areas of the river or reservoir, therefore, over the scale of the system as a whole, impacts would be small.
Alternative 2	• Temporary impacts would be the same as those described for 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. • Compared to Alternative 1, Alternative 2 is anticipated to have large temporary impacts to water quality because ESH construction under this Alternative affects substantially more acreage.
Alternative 3	• Temporary impacts would be the same as those described for Alternative 1. • Long-term impacts would be the same as those described for Alternative 2. • Compared to Alternative 1, Alternative 3 is anticipated to have slightly greater impacts to water quality; however, these localized contributions would be negligible to small over the scale of the system as a whole.
Alternative 4	• 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. • Over the long-term, negligible adverse impacts could result from localized areas of water temperature and dissolved oxygen alterations and negligible, beneficial impacts from reduced nutrients and pollutants. • Compared to Alternative 1, Alternative 4 is anticipated to have small impacts to water quality because of the additional localized impacts over the scale of the system as a whole.
Alternative 5	• 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. • Over the long-term, negligible adverse impacts could result from localized areas of water temperature and dissolved oxygen alterations and negligible, beneficial impacts from reduced nutrients and pollutants. • Compared to Alternative 1, Alternative 5 is anticipated to have slightly greater impacts to water quality; however, these localized contributions would be small over the scale of the system as a whole.

Alternative	Impacts to Water Quality
Alternative 6	• 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 impacts would be the same as those described for Alternative 5. • Compared to Alternative 1, Alternative 6 is anticipated to have slightly greater impacts to water quality; however, these localized contributions would be small over the scale of the system as a whole.

3.7.2.3 Impacts from Management Actions Common to All Alternatives

Project-specific impacts, either adverse or beneficial, from actions common to all plan alternatives would vary based on river flows, construction technique, existing conditions at each location, and the interaction of management actions.

Vegetation Management. All vegetation management treatment options involve the initial clearing of vegetation on selected sandbars. The primary and preferred method of vegetation control and removal would be the application of herbicides. The USACE would continue to use an imazapyr-based (e.g., Habitat) and/or a glyphosate-based (e.g., Rodeo) herbicide approved by the EPA for aquatic use. 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. Herbicide application has the potential to adversely affect the water quality of the Missouri River in localized areas by introducing pollutants directly into the hydrologic system or indirectly through runoff. Compared to spraying from all-terrain vehicles or by hand, the potential for adverse impacts would be higher when aerial spraying methods are used because of the potential for the herbicide to drift on air currents or wind gusts into the river.

The use of herbicides approved for aquatic habitats as well as appropriate herbicide application methods would prevent or minimize the degradation of water quality. The duration and intensity of treatment depends upon the size and density of the vegetation on the sandbar. Vegetation removal actions would include an initial treatment and ongoing annual maintenance treatments. Best Management Practices (BMPs) such as regularly checking equipment, placing safety measures to minimize the risk of spills, avoiding sensitive resources (e.g. wetlands), and maintaining an appropriate distance from water would be used to minimize any releases of fuels or other chemicals from equipment. The herbicides, imazapyr and glyphosate, will be used as a pre- and post-emergent treatment and would be sprayed directly on growing vegetation, avoiding water as much as possible. The desired outcome is that the herbicides would remain in the sand long enough to be taken up through the root of the plant in order to effectively slow down or eliminate vegetative growth rates; however a small amount may enter the water due to runoff. Overall, vegetation management practices would result in negligible adverse impacts on water quality. Current water quality monitoring will continue to determine if residue of the aquatically approved herbicides are detected in the water downstream of projects and that applicable federal, Tribal, and state water quality standards continue to be met.

Predator Management. Predator management techniques would not influence water temperature and dissolved oxygen, or result in increases or decreases in sediment and turbidity, nutrients, and other pollutants in the Missouri River. Therefore, these actions would not impact water quality within the reservoirs or river reaches of the Missouri River.

Human Restriction Measures. Human restriction measures would not influence water temperature and dissolved oxygen, or result in increases or decreases in sediment and turbidity, nutrients, and other pollutants including metals/metalloids in the Missouri River. Therefore, these actions would not impact water quality within the reservoirs or river reaches of the Missouri River.

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

Under Alternative 1, ESH would be constructed at an average rate of 107 acres per year. This acreage would be divided between the Garrison and Gavins Point Reaches. Mechanical ESH construction using dredging or heavy equipment such as backhoes, draglines, bulldozers, and scrapers would disturb sediment and increase the potential for local sediment loading into the river or reservoirs. Sediment disturbance would occur both during the excavation or dredging of materials from the river bottom and during the placement of sand. Therefore, the total acreage of sediment disturbance would be more than the acreage of ESH construction. During construction, there would be small temporary, adverse impacts on water quality due to increased sediment and turbidity levels in the river. The use of construction equipment could result in negligible temporary, adverse impacts to water quality from accidental leaks and spills of pollutants (e.g., oil, gas, lubricants). The potential for such impacts would be greater with water-based equipment compared to land-based equipment because of the direct contact with river water. These impacts would be minimized or eliminated by compliance with National Pollutant Discharge Elimination System (NPDES) permits, CWA Section 401 water quality certification, CWA Section 404 authorization, and by using construction best management practices, including an emergency response plan and pollution prevention plan. Furthermore, site-specific projects would perform elutriate testing on materials to test for contaminants before beginning construction. Activities that disturb the bed substrate, such as in-channel construction activities and placement of dredged spoil, can mobilize nutrients, organic matter, and other pollutants including metals/metalloids associated with the sediment resulting in negligible temporary, adverse impacts to water quality from increased nutrient and other pollutant levels. Mechanical ESH construction could mobilize anoxic sediments, reduced substances, or organic material during dredging operations. This could alter oxygen demand and decrease dissolved oxygen concentrations resulting in negligible localized, temporary, adverse impacts to water quality. Increased concentrations of sediment and turbidity, nutrients, and pollutants would occur in the river reaches where ESH is constructed and could extend into a downstream reservoir depending on the location of the construction and the rate of settling and dissipation; however, suspended sediment typically settles out at the head of the reservoirs. Mobilization of nutrients, organic matter, and other pollutants sequestered in the sediment could be minimized by avoiding areas of known contamination and using coarser fill material from the open channel areas.

For early life stage habitat for pallid sturgeon, Alternative 1 would construct 3,999 additional acres on the lower Missouri River between Ponca, Nebraska, and the confluence of the Mississippi River. Channel reconfiguration would modify the existing channel bed, banks, and existing Missouri River control structures and alter flow regimes and geomorphological processes such as erosion and sediment deposition resulting in the creation or improvement of habitat. Excavation and dredging would place dredged or excavated material into the Missouri River and modification of existing structures (e.g., dike, bank, and revetment notches) and placement of new structures would disturb river sediments, resulting in small, temporary, adverse impacts to water quality related to increases in sediment and turbidity concentrations. Additionally, sediment disturbance and placement of excavated material would disturb nutrients

and other pollutants including metals/metalloids associated with the sediment and would result in negligible, temporary, adverse impacts from increased nutrient and other pollutant loading. Disturbance of bed sediments could mobilize anoxic sediments, organic material, and reduced substances which could alter oxygen demand and decrease dissolved oxygen concentrations resulting in negligible, localized, temporary, adverse impacts to water quality. The use of construction equipment could result in negligible, temporary, adverse impacts to water quality from accidental leaks or spills of pollutants (e.g., oil, gas, lubricants). Water-based equipment would have a greater potential of causing impacts compared to land-based equipment because it is in direct contact with the river water. These impacts would be minimized or eliminated by compliance with a NPDES permit, CWA Section 401 water quality certification, CWA Section 404 authorization, and through the use of construction best management practices, including an emergency response plan and pollution prevention plan. Furthermore, site-specific projects would perform elutriate testing. Following construction, shallow water habitats typically have warmer water temperatures than deeper water habitats which influences dissolved oxygen concentrations. Therefore, there would be localized increases in water temperature and decreased in dissolved oxygen.

Under Alternative 1, spawning cue flows would be made up of bimodal spring pulses, which would be released in March and/or May from Gavins Point Dam. The flows and their associated impacts would decrease as the flow moves downstream. Therefore, impacts to water quality from the spawning cue flows would generally follow the same longitudinal pattern. The magnitude and duration of the spawning cue flows could be such that erosional and depositional processes would occur. Sediment could be eroded from the river channel resulting in small temporary, adverse impacts to water quality from increased sediment and turbidity and negligible temporary, adverse impacts from increased nutrients and pollutants released from the mobilized sediments, however, these increases would be very small compared to the overall larger river reach. The increased sediment, turbidity, and organic material could increase water temperatures and decrease dissolved oxygen concentrations in localized areas resulting in negligible temporary adverse impacts. The impacts would be small to negligible because the volume of water released would be small compared to natural flow variability and the impacts from the flows would be localized to small areas.

Habitat development includes establishment of native vegetation areas; creation of chutes, side channels, SWH, backwater areas, slack water habitats, wetlands, bottomland forest, and native prairie; and other restoration activities. The construction of habitat development would result in temporary disturbance to soils and river beds and banks. During construction of habitat, there would be small temporary, adverse impacts to water quality in the form of increased sediment loading to the river. Additionally, sediment disturbance and placement of excavated material would also mobilize nutrients, organic material, anoxic sediments, and other pollutants including metals/metalloids associated with the sediment and would potentially increase loading of these pollutants into the river. This would result in negligible temporary, adverse impacts from localized increases of nutrients and pollutants and potential increases in water temperatures and decreases in dissolved oxygen concentrations. The use of construction equipment could result in negligible temporary, adverse impacts to water quality from accidental leaks and spills of pollutants (e.g., oil, gas, lubricants). These impacts would be minimized or eliminated by compliance with a NPDES permit, CWA Section 401 water quality certification, CWA Section 404 authorization, and through the use of construction best management practices, including an emergency response plan and pollution prevention plan. After construction, there would be long-term, beneficial impacts on water quality from the creation or restoration of wetlands, riparian buffers, and other habitats that function as pollutant filters or nutrient sinks although benefits would likely be negligible at the regional level.

Land management operation and maintenance activities and best management practices would be performed in 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 that have not yet been restored. Depending on the method of noxious weed control, this action has the potential to result in loading of herbicides into the water. Similar to herbicide application under the vegetation management action, noxious weed control could have negligible temporary adverse impacts to localized water quality; however, compliance with state and federal regulations as well as herbicide application guidelines would minimize impacts to water quality. Controlled fires can affect both water quality and the local surface runoff regime, depending on the severity of the fire and the local fire regime (USFWS 2009). Fire removes vegetation and organic matter on the surface, exposes the soil to erosive processes, and can also reduce the infiltration capacity of soil, leading to more surface water runoff during precipitation events. These effects can lead to temporary increases in sediment loading in local surface waters. Fire management techniques that would minimize impacts include consideration of weather, season, and fuel conditions; using qualified crews; avoiding steep slopes; retaining vegetative buffers adjacent to surface waters; using appropriate firelines; and using the lowest-intensity fire necessary (USEPA 2005). The maintenance of roads could result in temporary soil disturbance and associated sedimentation in nearby waters. The use of heavy equipment during road maintenance could result in leaks or spills of pollutants (e.g., oil, gas, lubricants) that result in contamination of surface water in localized areas. Therefore, the small scale of land management operation and maintenance activities would result in negligible temporary, adverse impacts from pollutant loading.

Conclusion

Negligible to small temporary adverse impacts from vegetation management, construction of ESH and early life stage habitat, spawning cue flows, habitat development, and land management could occur. In the long term, habitat development actions would benefit water quality by decreasing nutrient and other pollutant levels although these benefits would likely be negligible at the regional level. Alternative 1 would not have significant impacts on water quality because adverse impacts would be mainly temporary and negligible to small especially when considered in the regional context.

3.7.2.5 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Under Alternative 2, the USACE would mechanically construct ESH at an average rate of 3,546 acres per year. This acreage would be divided between the Garrison Dam to Lake Oahe reach, the reach from Fort Randall Dam to the confluence of the Niobrara River, the riverine Lewis and Clark Lake reach from the Niobrara River to Lewis and Clark Lake, and the river reach downstream from Gavins Point Dam. General impacts to water quality from mechanical ESH construction are the same as those described under Alternative 1. Compared to Alternative 1, Alternative 2 would increase mechanically constructed ESH by an average of 3,439 acres annually. The impacts that result from sediment disturbance and habitat creation would be large because of the combined disturbance of both the increased ESH construction as well as the increased acreage disturbed for borrow areas. Compared to Alternative 1, there would be large impacts on water quality because the additional acres of sediment disturbance and habitat creation and the associated impacts are substantially greater than those under Alternative 1 and because the impacts would be spread over a large part of the system including reaches not directly affected under Alternative 1.

Under Alternative 2, channel reconfiguration would be used to create 10,758 acres of early life stage habitat for pallid sturgeon on the lower Missouri River between Ponca, Nebraska, and the mouth of the Missouri River. General impacts to water quality from channel reconfiguration are described under Alternative 1. Compared to Alternative 1, Alternative 2 would increase habitat by 6,759 acres. Although this is a substantial increase in habitat compared to Alternative 1, there would be small localized impacts on water quality because the additional acres and the associated impacts would be spread over the entire length of the lower Missouri River and best management practices would be used.

Under Alternative 2, spawning cue flows and their associated impacts would decrease as the flow moves downstream. The increased flows would result in impacts that are temporary but longer in duration than Alternative 1. The general impacts to water quality from spawning cue flows would be the same as those described under Alternative 1. In addition to the impacts discussed under Alternative 1, the spawning cue flows under Alternative 2 would also provide for the connection of low-lying lands adjacent to the channel. Connection of the river and low-lying areas would allow for increased infiltration and filtration of nutrients and pollutants within these habitats resulting in small long-term, beneficial impacts on water quality. Under Alternative 2, impacts to water quality from spawning cue flow would be greater than those under Alternative 1 due to the longer duration of the spawning cue pulses and the greater peak pulse magnitudes as well as the added connection of the river to low-lying areas. This change would be small because of the impact of existing flow control structures and the gradual attenuation of the flows with distance from Gavins Point Dam as well as the large scale over which the impacts would occur.

Under Alternative 2, the low summer flow conditions would provide SWH along the reach because the lower flows allow for riverine habitat that is typically under water at higher flows to become available. Shallow water heats up more easily thereby providing more warm water habitat. Water temperature affects dissolved oxygen concentrations with warmer water holding less oxygen than colder water. Therefore, implementation of low summer flows would increase the diversity of water temperature and dissolved oxygen conditions along the reach downstream from Gavins Point Dam. The lower flows would also decrease the rate of erosion along the river reach. Although this would reduce the amount of sediment inputs to the river from bed and bank erosion and would lower localized turbidity concentrations, the impacts would be negligible. Therefore, the low summer flow management action would have long-term, adverse impacts from the altered water temperature and dissolved oxygen conditions. These impacts would be perceptible on a local scale but would be small due to the large scale of the entire project area.

Under Alternative 2, the USACE would continue management of the System and approximately 77,410 acres of connected floodplain would be inundated. Floodplain connectivity would allow for floodplain functions such as infiltration and filtration of nutrients and pollutants resulting in small long-term, beneficial impacts on water quality. Floodplain habitat influences water temperature and dissolved oxygen concentrations resulting in long-term, adverse impacts on water quality warmer temperatures and decreased dissolved oxygen levels. These impacts would be small due to the large scale of the entire project area.

Under Alternative 2, the impacts to water quality from habitat development and land management on MRRP lands would be the same as those described under Alternative 1. Compared to Alternative 1, Alternative 2 would require a much greater amount of land acquisition and therefore, the impacts that result from habitat development and land management would be larger. Furthermore, the impacts under Alternative 2 would occur over all reaches from Ponca to the mouth of the Missouri River whereas under Alternative 1 the impacts

would only occur over two reaches. There would be large impacts on water quality because the additional acres of habitat development and land management and the associated impacts are substantially greater than those under Alternative 1 and because the impacts would be spread over a large part of the system including reaches not affected under Alternative 1.

Conclusion

Negligible to small temporary adverse impacts from vegetation management, construction of ESH and early life stage habitat, spawning cue flows, habitat development, and land management could occur. Negligible to small long-term adverse impacts from vegetation management, construction of early life stage habitat, low summer flows, floodplain connectivity, and habitat development could occur. Compared to Alternative 1, larger impacts to water quality would occur due to the large magnitude of acres of ESH construction and the longer duration and greater peak pulse magnitude of spawning cue flows under Alternative 2. In the long term, actions associated with spawning cue and low summer flows, floodplain connectivity, and habitat development would benefit water quality by reducing levels of nutrients, other pollutants, sediment, or turbidity although these benefits would likely be negligible to small at the regional level. Compared to Alternative 1, Alternative 2 is anticipated to have greater impacts to water quality however these contributions would be small over the scale of the Missouri River. Alternative 2 would not have significant impacts on water quality because adverse impacts would be negligible to small especially when considered in a regional context and long-term beneficial impacts would occur from multiple management actions.

3.7.2.6 Alternative 3 – Mechanical Construction Only

Under Alternative 3, the USACE would mechanically construct ESH at an average rate of 391 acres per year in years where construction occurs. This acreage would be divided between the Garrison Dam to Lake Oahe reach, the Fort Randall Dam to Lewis and Clark Lake reach, and the river reach downstream from Gavins Point Dam. General impacts to water quality from mechanical ESH construction are described under Alternative 1. There would be small, localized impacts on water quality because of additional ESH acres constructed under Alternative 3 compared to Alternative 1 and the associated impacts would be spread over a large part of the system including a reach not directly affected under Alternative 1.

Under Alternative 3, channel reconfiguration would be used to create up to 3,380 acres of new early life stage pallid sturgeon habitat, in the form of IRCs, on the lower Missouri River between Sioux City, Iowa, and the mouth of the Missouri River. General impacts to water quality from channel reconfiguration are described under Alternative 1. Alternative 3 would create approximately 619 fewer acres of habitat compared to Alternative 1. However, because the acres are spread over the river from Sioux City to the mouth of the river, changes would not be perceptible resulting in negligible impacts to water quality compared to Alternative 1.

Under Alternative 3, up to three spawning habitat sites would be constructed on the lower Missouri River. Sufficient understanding to characterize the necessary features of high quality pallid sturgeon spawning habitat does not exist at this time and it would be necessary to conduct studies prior to construction to clarify the necessary habitat specifications. It is assumed that spawning habitat creation would likely consist of re-engineering of existing channel morphology including modification of substrate, hydraulics, and geometry. Construction techniques would disturb the riverbed and banks and increase sediment and turbidity resulting in small temporary adverse impacts to water quality. Sediment disturbance would also disturb nutrients, organic matter, and pollutants associated with the sediment and would potentially

increase loading of these pollutants into the river resulting in negligible temporary adverse impacts to water quality. The use of construction equipment could result in negligible temporary, adverse impacts to water quality from accidental leaks and spills of pollutants (e.g., oil, gas, lubricants) with water-based equipment having the greater potential for impacts compared to land-based equipment because it is in direct contact with the river water. Adverse impacts would be minimized or eliminated through the use of construction best management practices. The increased turbidity and organic matter could increase water temperatures and reduce dissolved oxygen concentrations resulting in localized negligible, temporary adverse impacts. After construction, there would be long-term, beneficial impacts on water quality from the creation of riverine habitats and associated wetlands that function as pollutant filters. There would be more spawning habitat along the lower river under Alternative 3 resulting in increased impacts to water quality compared to Alternative 1. However, these impacts would be small because the additional acres and the associated localized impacts would be spread over the entire length of the lower Missouri River.

Under Alternative 3, the impacts to water quality from habitat development and land management on MRRP lands would be the same as those described under Alternative 1. Compared to Alternative 1, Alternative 3 would require less land acquisition and therefore, the impacts that result from habitat development and land management would occur over less acreage. Changes would not be perceptible resulting in negligible impacts to water quality compared to Alternative 1.

Conclusion

Negligible to small temporary adverse impacts from vegetation management, construction of ESH, early life stage and spawning habitat, habitat development, and land management could occur. Negligible to small long-term adverse impacts from vegetation management, construction of early life stage habitat, and habitat development could occur. In the long term, spawning habitat construction and habitat development actions would benefit water quality by decreasing nutrient and other pollutant levels although these benefits would likely be negligible at the regional level. Although ESH and early life stage habitat construction and habitat development and land management actions would occur over slightly different acreages compared to Alternative 1, the impacts from Alternative 3 would be similar. Alternative 3 would not have significant impacts on water quality because adverse impacts would be mainly temporary and negligible to small especially when considered in the regional context.

3.7.2.7 Alternative 4 – Spring ESH Creating Release

Under Alternative 4, the USACE would mechanically construct ESH at an average rate of 240 acres per year in years where construction occurs. This acreage would be divided between the Garrison Dam to Lake Oahe reach, the Fort Randall Dam to Lewis and Clark Lake reach, and the river reach downstream from Gavins Point Dam. General impacts to water quality from mechanical ESH construction are described under Alternative 1. Compared to Alternative 1, there would be small localized impacts on water quality from additional ESH acres under Alternative 4 as compared to Alternative 1 and the associated impacts would be spread over a large part of the system including a reach not directly affected under Alternative 1.

The spring ESH creating reservoir releases would cause scouring, erosion, sediment transport, and aggradation along the reaches downstream from the dams with the Fort Randall Dam to Lewis and Clark Lake and lower Missouri River reaches having greater impacts than the Garrison Dam to Lake Oahe reach because of higher releases. The amount of sediment and

turbidity transported depends on multiple factors including the existing area of sandbar habitat present prior to the flow release; mechanical sandbar creation would occur after this flow release. The amount of scouring and sediment mobilization in the lower Missouri River reach would be less than in the other reaches because of the existing self-scouring nature of the channel and the bank stabilization measures but would still have small temporary, adverse impacts to the sediment and turbidity regime along the reach. Increased nutrients and other pollutants could be released from the sediments however these increases would be very small compared to the overall larger river reach resulting in negligible temporary, adverse impacts to water quality. The water discharged from the dams is taken from the reservoir bottoms and is typically cooler than the receiving waters and characterized by higher dissolved oxygen concentrations resulting in adverse unnatural alterations downstream; however, this is dependent on the timing of the initiation of the stratification process. The discharges could result in small temporary adverse impacts to water quality from lower water temperatures and associated higher dissolved oxygen concentrations before the impacts are dissipated further downstream. Alternative 1 does not have a specific spring ESH creating flow. Therefore, the impacts under Alternative 4 would be greater than those under Alternative 1 but this change would be small because of the impact of existing flow control structures and the gradual attenuation of the flows with distance from Gavins Point Dam as well as the large scale over which the localized impacts would occur.

Under Alternative 4, the impacts to water quality from early life stage habitat construction, spawning habitat construction, and habitat development and land management on MRRP lands would be the same as those described under Alternative 3.

Conclusion

Negligible to small impacts would occur similar to Alternative 1 with additional temporary adverse impacts from the spring ESH creating reservoir release. In the long term, spawning habitat construction and habitat development actions would benefit water quality by decreasing nutrient and other pollutant levels although these benefits would likely be negligible. Although ESH and early life stage habitat construction and habitat development and land management actions would occur over slightly different acreages compared to Alternative 1, the impacts from Alternative 4 would be similar when considered in context with the entire system. Alternative 4 would not have significant impacts on water quality because adverse impacts would be mainly temporary and negligible to small especially when considered in the regional context.

3.7.2.8 Alternative 5 – Fall ESH Creating Release

Under Alternative 5, the USACE would mechanically construct ESH at an average rate of 309 acres per year in years where construction occurs. This acreage would be divided between the Garrison Dam to Lake Oahe reach, the Fort Randall Dam to Lewis and Clark Lake reach, and the river reach downstream from Gavins Point Dam. General impacts to water quality from mechanical ESH construction are described under Alternative 1. There would be small, localized impacts on water quality because of the additional ESH acres compared to Alternative 1 and the associated impacts would be spread over a large part of the system including a reach not directly affected under Alternative 1.

The magnitude, duration, and longitudinal pattern of the fall ESH creating reservoir release, as well as the impacts to water quality from implementation of the release, would be the same as those described for sediment, turbidity, nutrients, and pollutants under Alternative 4 for the spring ESH creating reservoir release. However, the fall ESH creating release under Alternative

5 would have different impacts on water temperature and dissolved oxygen. The water discharged from the dams during the fall is typically warmer than the receiving waters and characterized by lower dissolved oxygen concentrations resulting in adverse, unnatural alterations downstream. Therefore, the discharges could result in small temporary adverse impacts to water quality. However, this is dependent on the timing of the initiation of the stratification process; if stratification has broken down by the time the fall ESH creating reservoir release is implemented the water temperature and dissolved oxygen levels would generally be similar to existing inter-reservoir conditions. Alternative 1 does not have a specific fall ESH creating flow. Therefore, the impacts under Alternative 5 would be greater than those under Alternative 1, but this change would be small because of the impact of existing flow control structures and the gradual attenuation of the flows with distance from Gavins Point Dam as well as the large scale over which the localized impacts would occur.

Under Alternative 5, the impacts to water quality from early life stage habitat construction, spawning habitat construction, and habitat development and land management on MRRP lands would be the same as those described under Alternative 3.

Conclusion

Negligible to small impacts would occur similar to Alternative 1 with additional temporary adverse impacts from fall ESH creating reservoir release. In the long term, spawning habitat construction and habitat development actions would benefit water quality by decreasing nutrient and other pollutant levels although these benefits would likely be negligible. Although ESH and early life stage habitat construction and habitat development and land management actions would occur over slightly different acreages compared to Alternative 1, the impacts from Alternative 5 would be similar when considered in context with the entire system. Alternative 5 would not have significant impacts on water quality because adverse impacts would be mainly temporary and negligible to small especially when considered in a regional context.

3.7.2.9 Alternative 6 – Pallid Sturgeon Spawning Cue

Under Alternative 6, the USACE would mechanically construct ESH at an average rate of 303 acres per year in years where construction occurs. This acreage would be divided between the Garrison Dam to Lake Oahe reach, the Fort Randall Dam to Lewis and Clark Lake reach, and the river reach downstream from Gavins Point Dam with the most construction in the reach downstream from Gavins Point Dam and the least in the Fort Randall Dam to Lewis and Clark Lake reach. General impacts to water quality from mechanical ESH construction are described under Alternative 1. There would be small localized impacts on water quality because of the additional acres of ESH compared to Alternative 1 and the associated impacts would be spread over a large part of the system including a reach not directly affected under Alternative 1.

Under Alternative 6, spawning cue flows and their associated impacts would decrease as the flow moves downstream. Furthermore, the increased flows would only last two days at the peak with a gradual decrease in flow levels over time resulting in temporary impacts with a similar duration as under Alternative 1. The general impacts to water quality from spawning cue flows would be the same as those described under Alternative 1. However, under Alternative 6, impacts to water quality from spawning cue flow would be greater than those under Alternative 1 due to the greater peak pulse magnitudes but change would be small because of the impact of existing flow control structures and the gradual attenuation of the flows with distance from Gavins Point Dam as well as the large scale over which the impacts would occur.

Under Alternative 6, the impacts to water quality from early life stage habitat construction, spawning habitat construction, and habitat development and land management on MRRP lands would be the same as those described under Alternative 3.

Conclusion

Negligible to small impacts would occur similar to Alternative 1. In the long term, spawning habitat construction and habitat development actions would benefit water quality by decreasing nutrient and other pollutant levels although these benefits would likely be negligible. Although ESH and early life stage habitat construction and habitat development and land management actions would occur over slightly different acreages and spawning cue flows would have greater peak pulse magnitudes compared to Alternative 1, the impacts from Alternative 6 would be similar when considered in context with the entire system. Alternative 6 would not have significant impacts on water quality because adverse impacts would be mainly temporary and negligible to small especially when considered in a regional context.

3.7.2.10 Tribal Resources

Many Tribes in the basin have voiced water quality concerns related to the Missouri River. As described previously, given the use of EPA-approved herbicides, use of best management practices, and localized application of herbicides on individual sandbars, significant impacts to water quality are not anticipated in association with Tribal lands. USACE would continue to conduct monthly surface water quality sampling from May to September at three locations: (1) near Bismarck, North Dakota (near-surface water sample; collection taken from off the bank or boat ramp); (2) Beaver Creek located at RM 1256.0 (near-surface sample; collection taken from boat in river); and (3) Mobridge, South Dakota (near-surface and near-bottom samples; collection taken from boat in river). The samplings have been ongoing since 2013 and would continue into the future as needed. The water quality monitoring will determine if residue of the aquatically approved herbicides (i.e., imazapyr and glyphosate) is detected in the water and that applicable Tribal, state, and federal water quality standards are met.

3.7.2.11 Climate Change

The climate change scenario states that there will likely be increased air temperature, precipitation, and streamflow in the future. Higher air temperatures would likely influence water temperature especially in areas of low river flow or low reservoir elevations resulting in warmer water temperatures. Furthermore, increased air temperatures and the resulting increased water temperatures could influence the amount of time that the mainstem reservoirs are thermally stratified. The duration of stratification could increase with the temperature increase or, in shallower reservoirs, the thermal stratification could be more permanent (Georgakakos et al. 2014). This loss of polymictic conditions could concentrate nutrients and pollutants and deplete dissolved oxygen concentrations. Overall, most models predict rain events will be less frequent but more intense and heavy, resulting in relatively longer dry periods interspersed with heavy rainfall. These periods of intense rain could increase runoff, mobilize land-based particulates, and increase sediment and pollutant loading in the Missouri River. Models of several climate change scenarios show that all scenarios result in some degree of increased sediment loading. Stormwater traveling over impervious surfaces warms up and could affect the water temperature in the receiving water. Seasonally, more winter precipitation occurs in the form of rain rather than snow, potentially resulting in an increase in stormwater runoff. Therefore, the general impacts of climate change under all alternatives would consist of adverse impacts from

altered water temperature regimes and, by association, dissolved oxygen conditions, as well as potential increases in sediment loading and nutrient and other pollutant loading.

Under Alternative 1, climate change and associated water temperature alterations could specifically affect the initiation of the May spawning cue flow. The initiation of the May pulse released from Gavins Point Dam would occur between May 1 and May 19 and after the second daily occurrence of a water temperature reading of 16°C or higher. Climate change related increases in water temperatures could result in earlier initiation of the May pulse. Overall, there would be no change to water quality; however, the localized impacts that result from the spawning cue flow could occur earlier.

Under Alternative 2, climate change and associated water temperature alterations could specifically affect the initiation of the May spawning cue flow. The initiation of the second pulse released from Gavins Point Dam relies on water temperature conditions. Climate change related increases in water temperatures could result in a change to the date of initiation of the May pulse and, therefore, the localized impacts resulting from the spawning cue flow. Also, the proposed low summer flow releases downstream from Gavins Point Dam could result in greater water temperature issues, especially in the reach between the dam and Ponca, Nebraska, due to the river depth and braiding present in this area.

There are no specific impacts to water quality from climate change under Alternatives 3, 4, and 5 other than the general impacts described above for all alternatives.

Under Alternative 6, there could also be potential changes to the initiation of the May spawning cue flow due to the influence of climate change on the water temperature. The initiation of the May pulse released from Gavins Point Dam would begin on May 18 or later depending on the water temperature conditions (i.e., 16°C to 18°C). Climate change related increases in water temperatures could result in an earlier initiation date and, therefore, the earlier realization of the localized impacts from the pulse. While climate change could influence water quality, the impacts of the alternatives on water quality are not expected to change as a result.

3.7.2.12 Cumulative Impacts

Past, present and reasonably foreseeable future actions, projects, and programs have both temporary and long-term impacts on water quality. Temporary impacts result from construction activities, including those for the mainstem reservoirs, the BSNP, levee construction, oil and natural gas production, habitat construction and creation, and development actions. Temporary impacts include adverse impacts from increased levels of sediment, turbidity, nutrients, and other pollutants as well as impacts from alterations to water temperature and dissolved oxygen conditions.

The mainstem reservoirs have altered all aspects of water quality over a large portion of the river. Specifically, the dams and reservoirs have resulted in seasonally depleted dissolved oxygen in reservoirs; discharges of cold water in the tailwaters of some dams and the potential for higher concentrations of nitrogen, phosphorus, and other pollutants in reservoirs during low elevation periods. The BSNP and levee construction have decreased sediment and turbidity resulting in beneficial impacts as well as decreased the habitats that provide nutrient and pollutant filtration throughout the lower river resulting in adverse impacts.

Surface water withdrawals for agriculture, municipal, and industrial uses, as well as groundwater withdrawals, such as those from oil and natural gas production, could lower water flows or

elevations in the river and reservoirs and impact water quality. In these conditions, water heats up more rapidly; dissolved oxygen concentrations decrease; and nitrogen, phosphorus, and other pollutants become concentrated, resulting in small to large adverse impacts to water quality. Additionally, return flows would adversely impact water quality with increased nitrogen and phosphorus concentrations, higher localized water temperatures, and potentially higher levels of other harmful pollutants.

Urban, residential, transportation/utility, commercial, and industrial development on the floodplain result in temporary impacts. Small long-term adverse impacts to water quality result from stormwater runoff and discharges characterized by increased water temperatures, sediment and turbidity, nutrients, and other pollutant loads. Agricultural actions including floodplain animal pasturing and crop production result in large long-term adverse impacts from increased loading of nutrients and other pollutants.

The past, present, or reasonably foreseeable future actions of USACE Continuing Authority Programs associated with ecosystem restoration, and the actions of other federal agencies that focus on land and river conservation and management and restoration of natural habitats would result in long-term beneficial impacts for water quality including reduction of sediment, nutrient, and other pollutant loading.

Present and reasonably foreseeable future actions related to nutrient reduction and ammonia regulations could result in large long-term beneficial impacts to water quality. Iowa and Missouri have developed nutrient reduction strategies, which set nutrient reduction goals. Long-term, beneficial impacts to water quality are possible over time. New aquatic life ambient criteria for ammonia in freshwater were recommended by the U.S. Environmental Protection Agency in 2013. Although these criteria have not yet been adopted by states within the Missouri River basin, potential adoption would decrease concentrations of ammonia in the river.

Cumulative impacts would be the same for Alternatives 1–6. Overall, cumulative actions from past, present, and reasonably future actions would be long-term, adverse or beneficial to water quality. Cumulative actions significantly affect water quality on the Missouri River by altering all aspects of water quality over a large portion of the river. The management actions under Alternatives 1–6 are anticipated to have temporary adverse and long-term adverse and beneficial impacts from alteration of water quality parameters. When combined with other past, present, and reasonably foreseeable future actions, Alternatives 1–6 would result in both adverse and beneficial impacts largely based on changes to levels of sediment, turbidity, nutrients, and other pollutants and from alterations to water temperature and dissolved oxygen conditions. The implementation of Alternative 1 would provide a small contribution and implementation of Alternatives 3–6 would provide a negligible contribution to the cumulative impacts to water quality, based on the localized scale of the impacts. The implementation of Alternative 2 would provide a large contribution to the cumulative impacts because the scope of the impacts from Alternative 2 encompasses a large part of the project area and Alternative 2 contains a higher intensity of construction and flow management actions.

3.8 Air Quality

3.8.1 Affected Environment

Air quality is protected under several provisions of the Clean Air Act, including the national ambient air quality standards (NAAQS), which are described in greater detail in this section. Air quality regulatory oversight is administered by the EPA and various state and regional agencies within the area where management action would occur. Air quality administration, regulation, and attainment status are discussed in this section. States covered include Montana, North Dakota, South Dakota, Nebraska, Kansas, Iowa, and Missouri.

3.8.1.1 National Ambient Air Quality Standards

The NAAQS consist of numerical standards for air pollution caused by “Criteria” air pollutants identified by the EPA. These air quality standards are given “primary” and “secondary” status for protecting public health and public welfare, respectively. Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings. “Criteria” pollutants include carbon monoxide, nitrogen dioxide, ozone, lead, particulate matter with particles less than 10 microns in diameter, particulate matter with particles less than 2.5 microns in diameter, and sulfur dioxide.

3.8.1.2 Current Air Quality Conditions

The predominant 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 (USEPA 2015a).

A non-attainment area is defined as a locality where air pollution levels persistently exceed NAAQS or that contributes to ambient air quality in a nearby area that fails to meet standards. Six designated non-attainment and partial non-attainment areas exist within the lower portion of Pottawattamie County, Iowa, for lead. In Missouri, Franklin County, St. Charles County, St. Louis County, and St. Louis City are designated as non-attainment areas for 8-hour ozone and particulate matter with particles less than 2.5 microns in diameter. Additionally, Jackson County, Missouri, is designated as being a partial non-attainment area due to exceedances of the sulfur dioxide standard in the Kansas City area (USEPA 2016).

A large portion of the area where management actions would occur can be characterized as rural with generally good air quality. Mobile emissions sources occur from agricultural operations and from major roadways such as interstate highways and industrial operations within the vicinity of the river. The main transportation corridors of interstates in Nebraska, Kansas, and Missouri contribute to air pollution from mobile sources, and industrial development in the cities also contributes to air pollution. The heavily trafficked corridors between Omaha and Kansas City and from Kansas City to St. Louis, which runs parallel to the Missouri River, contributes considerably to air pollution along that portion of the mainstem river. Also, numerous electric power facilities located near the Missouri River in Missouri constitute major sources of sulfur dioxide emissions.

3.8.1.3 Sources of Greenhouse Gas Emissions and Offsets

A major contribution to greenhouse gas emissions along the Missouri River comes from industrial activities. These activities are widely dispersed and consist of stationary source emissions. The primary stationary sources of greenhouse gases are coal-fired power generation facilities that generally operate along the upper Missouri River. There are also 22 thermal power plants located along or very close to the Missouri River. In addition, there is an electricity conversion station that is used when one of the thermal power plants is shut down. Several hydropower and wind-powered generation facilities function within the area where management actions would occur, generating electricity by far less carbon-intensive means. These facilities represent an offset to greenhouse gas emissions in that they are generating electricity by means other than the burning of fossil fuel.

Greenhouse gasses are also produced from mobile sources in the project area. These sources include motor vehicles such as trucks and boats used for transportation of goods and materials along the Missouri River. Emissions from these vehicles impact regional air quality incrementally through other contributions including to levels of criteria air pollutants such as carbon monoxide, nitrogen oxide, and volatile organic compounds.

3.8.2 Environmental Consequences

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.

3.8.2.1 Impacts Assessment Methodology

The analysis of impacts to air quality includes impacts from mechanical ESH construction and channel reconfiguration for creation of early life stage habitat for pallid sturgeon (SWH and IRC). While the acres and extent of implementation of mechanical ESH construction and channel reconfiguration for creation of early life stage habitat for pallid sturgeon (SWH and IRC) varies by alternative, the type and duration of impacts to air quality would be similar and overall impacts to air quality from management actions are expected to be similar for all alternatives. Therefore, impacts from management actions on air quality are common to all alternatives and are not assessed individually for each alternative.

The geographic scope of the following analysis is comprised of the air sheds associated with portions of each state containing lands located within the Missouri River floodplain. These states include Montana, North Dakota, South Dakota, Nebraska, Kansas, Iowa, and Missouri. The counties with air quality attainment designations in areas where management actions would occur are described in more detail in Section 3.8.1, Affected Environment.

Assessments of impacts on air quality are also included in the sections discussing thermal power, navigation, and hydropower. For a more detailed discussion of these impacts refer to Section 3.17, Thermal Power; Section 3.15, Navigation; and Section 3.13, Hydropower.

The No Action Alternative is considered the baseline against which the other alternatives are measured. Under the No Action Alternative, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, the No Action Alternative does 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.

3.8.2.2 Summary of Environmental Consequences

Environmental consequences relative to air quality include localized adverse impacts on air quality from vehicle emissions during mechanical ESH construction and channel reconfiguration for creation of early life stage habitat for pallid sturgeon that would be negligible and limited to construction periods. Greenhouse gas emissions associated with habitat construction would be hard to discern in the regional context.

The one-time spawning cue test (Level 2) release that may be implemented under Alternative 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.

3.8.2.3 Impacts Common to All Alternatives

Impacts to Air Quality

Mechanical ESH construction and channel reconfiguration for creation of early life stage habitat for pallid sturgeon involves the use of heavy equipment. Localized, indirect impacts to air quality would occur from vehicle emissions associated with these activities from transportation of personnel and equipment to and from a job site on a daily basis during construction. Emissions from equipment and vehicles would be temporary and would have relatively low emissions levels and any air pollutants are expected to disperse quickly. The increases emissions would not be expected to be high enough to result in any areas entering non-attainment for any NAAQS parameters and would contribute no or negligible impacts in areas that are currently designated as non-attainment for any NAAQS parameters.

Calculation of emissions would be part of the site specific analysis once project information about equipment, fuel usage, and construction are known. Best management practices would also be implemented, such as powering off equipment when not in use to reduce impacts to air quality.

Conclusion

Localized adverse impacts to air quality from vehicle emissions during mechanical ESH construction and channel reconfiguration for creation of early life stage habitat for pallid sturgeon would be negligible and limited to construction periods. Impacts from management actions would not have significant impacts on air quality because adverse impacts would be negligible and localized.

3.8.2.4 Tribal Resources

While Tribal resources do occur within the airsheds that intersect areas within the Missouri River floodplain where management actions would occur, only localized impacts to air quality from vehicle and equipment emissions during mechanical ESH construction and channel

reconfiguration for creation of early life stage habitat for pallid sturgeon are expected. These impacts would be negligible and limited to construction periods in localized areas.

3.8.2.5 Climate Change

Climate change would not influence the impacts of the management actions related to vehicle emissions on air quality. Therefore, it is assumed that the conclusions described for all alternatives would not vary substantially under the expected climate change scenario (Climate Change Assessment – Missouri River Basin, available on the MRRP website at www.moriverrecovery.org).

3.8.2.6 Cumulative Impacts

Impacts to air quality would occur as a result of past, present and reasonably foreseeable future plans and actions in the region—including past Missouri river mainstem reservoir system construction; oil and gas production; urban, residential, commercial and industrial floodplain development; crop production; transportation and utility corridor development; and other state and federal programs and actions which contribute to emissions of air pollutants. These actions effectively contribute to air quality exceedances through incremental increases in emissions and result in adverse effects to regional air quality. Existing regional mobile source emissions from vehicles are expected to continue, resulting in long-term adverse impacts to regional air quality. Long-term adverse impacts occur from stationary sources such as power generation facilities. Temporary adverse effects occur in the area where management actions would occur from sources such as construction activity associated with floodplain development.

When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of any of the alternatives would result in negligible impacts to regional air quality deterioration through emission of criteria air pollutants. Greenhouse gas emissions associated with habitat construction would be hard to discern in the regional context. Implementation of any of the alternatives would provide no contributions to negligible contributions to these cumulative impacts from vehicle emissions associated with construction of ESH and early life stage habitat for pallid sturgeon.

3.9 Cultural Resources

3.9.1 Affected Environment

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

> An 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 6.0 of this EIS. Numerous cultural resource sites have been identified within the Missouri River Basin. Most of these cultural resource sites included represent archaeological sites, historic 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. Table 3-24 summarizes the total number of cultural resource sites included in this analysis. A complete discussion of how these sites were selected and how data was obtained can be found in the “Cultural Resources Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

Table 3-24. Recorded Cultural Resource Sites in Analysis

Geographic Area	Number of Sites
Fort Peck Lake	53
Montana Riverine Sections	136
North Dakota Riverine Sections	444
Lake Sakakawea	838
South Dakota Riverine Sections	13
Lake Oahe	1,047
Lake Sharpe	333
Lake Francis Case	359
Lewis and Clark Lake	57

Geographic Area	Number of Sites
Nebraska Riverine Sections	661
Iowa Riverine Sections	336
Missouri Riverine Sections	2,555
Kansas Riverine Sections	72

Note: Sites without reliable elevation and/or location information were excluded from the analysis, as were sites in riverine settings determined ineligible for inclusion in the National Register of Historic Places.

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” were all 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. Figure 3-50 shows the mainstem reservoir reaches, where the “reservoir sites” are located. The map also shows the Missouri River floodplain, which represents the locations of “riverine sites,” both between the mainstem reservoirs and in the Lower Basin.

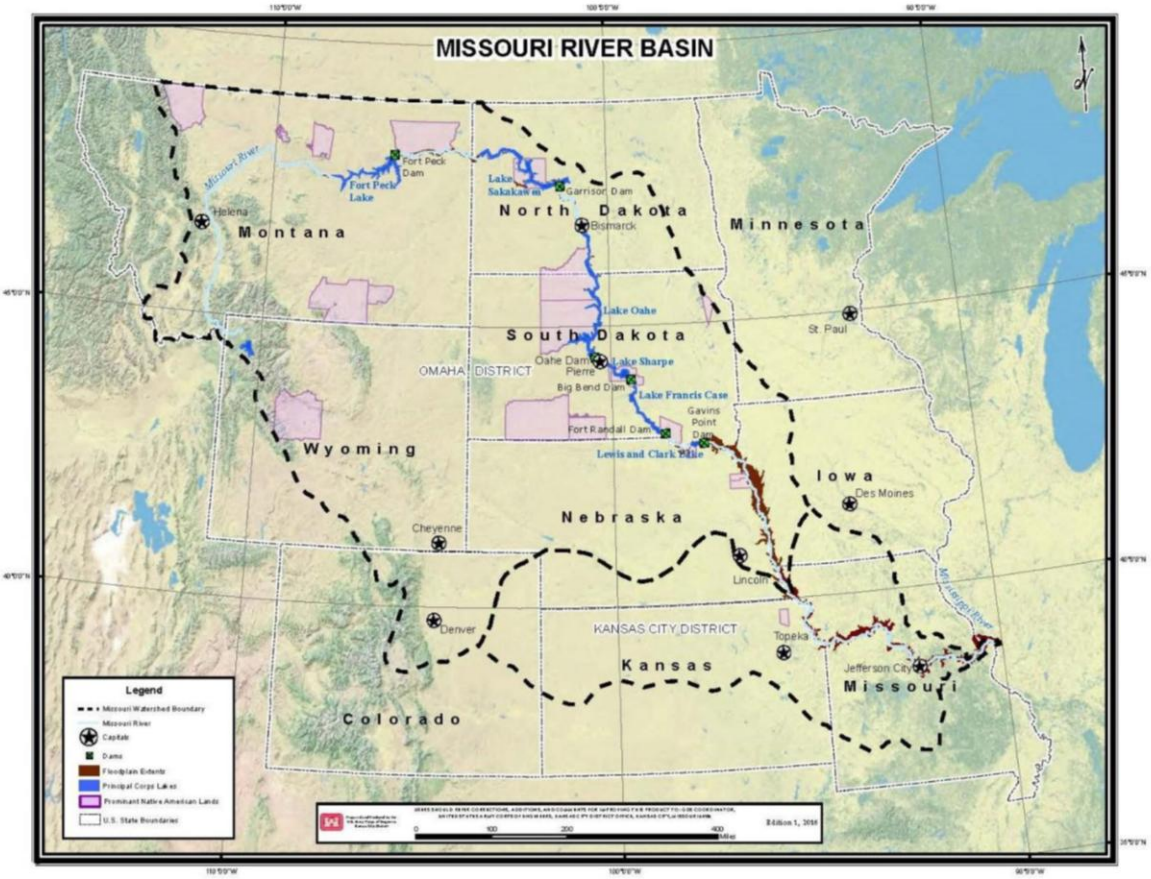


Figure 3-50. Missouri River Floodplain

Tribal members place importance on archaeological sites because they represent tangible evidence of Native American occupation and lifeways within an area. Many individuals and groups understand cultural resources to include places, things, areas, or landforms of significant spiritual or community importance, which are not necessarily archaeological in nature. Examples include places used for plant gathering, burial, and ceremonial or community practices. These historic properties of religious and cultural significance to Indian Tribes are defined by the community to whom the property is important, and often involve sensitive information that the community may consider confidential. Avoidance of these properties often may only be achieved through consultation.

3.9.1.1 Cultural Context

The Missouri River floodplain contains a wide variety of cultural resource types that span from the earliest recorded Native American inhabitants dating to the Paleo-Indian period (approximately 11,000 years ago or earlier) through modern historic times. Prehistoric cultural resource sites differ somewhat depending on the culture inhabiting a specific segment of the Missouri River. These differences become pronounced in more-recent sites and are generally manifested in the archeological record by differences in habitation structure styles and construction, site size, and types of artifacts. However, there are general site types that occur along the entire river, including habitation sites, processing sites, lithic scatters, human burial sites, and rock art. Habitation sites range from long-term, permanently occupied village sites to very short-term camp sites associated with resource procurement activities. Typical burial sites on the Missouri River include rock cairns and burial mounds associated with late prehistoric populations. Rock art such as petroglyphs, although uncommon in the floodplain, have been found on bluff faces along the floodplain peripheries.

As with prehistoric resources, historic cultural resources vary in type and age by river segment. For example, European and American settlement began much earlier in the lower Missouri River (1700s to 1830s) than much of the upper basin, and it is often much easier to associate these sites to specific groups at specific times. Historic cultural resource sites are associated with: Native American occupation of the river; colonial ownership and exploration; territorial American settlement; the Antebellum and Civil War period; industrial development; river transportation; and dam building and river control. Sites associated with these eras and themes are many and varied. Typical historic cultural resource sites include: Native American village sites, burial locations, trails and TCPs; Euro-American shipwrecks, homesteads, cemeteries, landings, roads, and bridges; and sites and structures related to military exploration and activities including Lewis and Clark camp sites, forts, trails, and battlefields.

3.9.1.2 Cultural Resources in Reservoir Settings

Cultural resources located within reservoir settings are particularly susceptible to impacts from water-surface elevations. Cultural resource sites located below the minimum normal pool elevation were subject to dramatic changes during the initial filling of the reservoir; however, the water column and subsequent siltation have since provided these sites with some protection from further erosion and looting. Submerged cultural resource sites that are located near the minimum-normal pool elevation (i.e., the elevation of the top of each reservoir's "Carryover Multiple Use Zone" as defined in Section 3.2 "River Infrastructure and Hydrologic Processes") may still become exposed during periods of low water, increasing risks of exposure and access, which could result in erosion and looting.

Cultural resource sites located above maximum-normal pool elevation (i.e., the elevation of the top of each reservoir's "Annual Flood Control and Multiple Use Zone" as defined in Section 3.2) have been subject to fewer direct impacts related to reservoir construction and operation than the sites within or below normal pool elevations. However, these sites have since been subject to risk from increased activity/access related to recreation, though also subject to protection through additional federal regulations (Lenihan et al. 1981). These sites located above the maximum-normal pool elevation may also be impacted by erosion during periods of higher-than-normal water levels during flood events. In these instances, a site may become inundated, resulting in greater risk of erosion along the water line, particularly if the pool elevation remains high enough for long enough to decimate existing vegetation.

Cultural resource sites located within the normal range of pool elevations are subject to "continual-to-intermittent erosion due to nearshore wave action and wave-induced currents…enhanced by the absence of protective vegetation cover" (Lenihan et al. 1981). Further these sites are easily accessible by watercraft, placing them at a greater risk of looting and vandalism compared to sites either above or below normal pool levels. Because these sites located within the normal range of pool elevations are subject to near-continuous risk, they are considerably less sensitive to fluctuations in pool elevation that are outside the normal range.

3.9.1.3 Cultural Resources in Riverine Settings

Similar to cultural resource sites located above maximum-normal pool elevation at a reservoir, cultural resource sites located along river banks or in riverine floodplains are also subject to increased risk of erosion when river elevations rise during flood events. Unlike reservoir sites, which are located on federal fee owned land, most of the sites in riverine settings are on land that is not federally owned.

For the purpose of this analysis, cultural resource sites located in riverine settings have been sub-divided into two groups: (1) sites that have some physical barrier, such as a levee, providing some protection from erosion from flooding; and (2) sites that are unprotected. Cultural resource sites that are protected are less frequently impacted by erosion although they may be impacted during times of high water if the levees/barriers protecting them are overtopped. While these sites may be protected from erosion, they are still susceptible to other impacts, such as vandalism and looting, as well as unintentional impacts associated with maintenance of flood-risk management infrastructure.

Unprotected cultural resource sites located close to river banks are subject to the most risk of erosion, relative to other riverine sites. Depending on their proximity, these sites may be subject to erosion on a daily basis or during relatively minor high-water events. Erosion impacts these cultural resources by destroying cultural materials and degrading intact cultural deposits. The exposure of these sites along shorelines may lead to both intentional and unintentional damage. Cultural materials exposed by erosion may be more obvious to the public and could lead to greater risk of vandalism and looting.

3.9.1.4 Results of Existing Conditions Modeling

Modeling of critical water elevation thresholds was conducted on current cultural resources data to determine the number of sites affected and the number of days that those cultural resource sites were at greater risk, relative to other times. Within the reservoir settings, cultural resource site data were grouped into those above normal pool elevation, those located within the normal pool elevation, and those below normal pool elevation. For riverine settings, sites were grouped

as sites located behind levees and sites not behind levees. Additionally, on the riverine reaches cultural resource site data were grouped into 5-mile stretches and assigned to the cross section of the river closest to that stretch. The data was then summarized by state. A complete explanation is available in the “Cultural Resources Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

3.9.1.5 Cultural Resources at Risk in Reservoir Settings

Initial screening of sites located within the mainstem reservoir indicates that all reservoirs have sites susceptible to erosion or looting based on fluctuations in pool elevation. Table 3-25 displays the total number of sites which may be subject to variation in risk over the POR.

Table 3-25. Affected Sites (Outside Normal Pool Elevation)

Location	Sites Above Normal Pool Elevation	Sites Below Normal Pool Elevation
Fort Peck Lake	22	6
Lake Sakakawea	382	59
Lake Oahe	215	175
Lake Sharpe	8	16
Lake Francis Case	166	30
Lewis and Clark Lake	28	3

In general, on the reservoirs, a greater number of sites are subject to increased risk of erosion when water levels are above the normal operating levels (as compared to the number of sites subject to risk of exposure when water levels are below the normal operating levels); however, most of these sites located above the maximum-normal pool elevations are not subject to these erosional forces every year or for long periods. Reservoirs with sites exposed during periods of low water are easily accessed by individuals on the reservoirs who may damage or remove artifacts and materials either intentionally or unintentionally.

3.9.1.6 Cultural Resources at Risk in Riverine Settings

The analysis of sites in riverine settings differentiates between sites located behind levees, and sites not located behind levees. Sites located behind levees are not assumed to be at greater-than-normal risk until flood waters reach a modeled elevation that would overtop the levee. Sites not located behind levees are assumed to be at greater-than-normal risk when modeled water levels reached the site’s lowest elevation. In either case these sites, located in riverine settings of the Missouri River floodplain, were normally only impacted during flood events. Table 3-26 summarizes the number of inventoried sites impacted under any alternative by state.

Screening efforts indicate that, outside of the mainstem reservoir system, Montana had modeled impacts on five known riverine sites during the POR, and North and South Dakota had no known sites impacted.

Table 3-26. Summary of Affected Floodplain Sites

	Unprotected Sites	Levee Protected Sites
Montana	5	0
North Dakota	0	0
South Dakota	0	0
Iowa	54	121
Nebraska	134	24
Kansas	21	4
Missouri	939	196

Note: Sites analyzed in "reservoirs settings" were not included in analysis of riverine sections of the state.

3.9.2 Environmental Consequences

3.9.2.1 Impacts Assessment Methodology

The primary impacts to cultural resource sites from the MRRMP-EIS alternatives would be related to modifications of flow and changes in reservoir pool elevations that could change the frequency of risk of erosion and/or vandalism and looting. The analysis was based on an assumption that cultural resource sites that are typically submerged face a greater risk of exposure to vandalism and looting as well as erosion when river/pool elevations decrease. Modeled impacts to cultural resource sites that are typically above the normal river/reservoir surface level elevation are subject to greater risk of erosion when river/pool elevations increase. More simply, cultural resource sites (whether located on reservoirs or riverine reaches) were sensitive to changes in water-surface elevations.

USACE recognizes that numerous cultural resource sites within the study area have not yet been identified. Due to the size and scope of this analysis, it was necessary to assume that yet-to-be-discovered sites would be affected by MRRMP-EIS alternatives in a manner similar to identified sites. USACE used current site information for this analysis. Impacts to sites were modeled with HEC-RAS hydraulic modeling software to determine the effect of various flows to these sites. The primary metric used to compare alternatives was "site-days," which were calculated by counting each day that each cultural resource site would be at greater-than-normal risk, then summing these counts across all cultural resource sites in a given area. See the "Cultural Resources Environmental Consequences Analysis Technical Report" (www.moriverrecovery.org) for a full discussion of the methods used to evaluate impacts to cultural resources based on changes in flow management. Specific site names, numbers, and locations were not disseminated for this effort.

For habitat construction and other non-flow related management actions, assessments were made based on impacts from similar ongoing activities within the study area. Additionally, due to the size and scope of the MRRMP, specific impacts on individual sites were not evaluated. NHPA Section 106 and 110 will be followed as management plan actions are implemented based on NHPA Programmatic Agreements and consultations.

3.9.3 Summary of Environmental Consequences

Screening of sites located within the study area indicated variable impacts to cultural resource sites, but most alternatives impact the same individual sites. See Tables 3-27 and 3-28 for a summary of individual cultural resource sites impacted by each alternative. These impacts are generally related to fluctuations in water levels which resulted in greater risk, either from erosion or access that correlates to greater likelihood of looting. In general, the more water levels fluctuate, the greater the degree and magnitude of impacts to cultural resource sites. The primary differences between the MRRMP alternatives were observed changes to the frequency and duration which sites were subject to greater risk, rather than differences in the number of sites affected. Further identification of specific sites may need to be undertaken in order to better understand impacts to specific properties should management actions require significant modifications to water storage and releases within the system.

Table 3-27. Total Number of Individual Reservoir Sites Affected

Location	Location Relative to Normal Pool Elevation	Alternative					
		1	2	3	4	5	6
Fort Peck Lake	Above	11	11	11	11	22	11
	Below	6	5	6	6	6	6
Lake Francis Case	Above	166	166	166	166	124	166
	Below	30	30	30	30	30	30
Lake Oahe	Above	215	215	215	215	215	215
	Below	175	175	175	175	175	175
Lake Sakakawea	Above	382	382	382	382	382	382
	Below	58	59	58	59	58	59
Lewis and Clark Lake	Above	28	28	28	28	28	28
	Below	3	3	3	3	3	3
Lake Sharpe	Above	8	8	8	8	8	8
	Below	16	16	16	16	16	16

Table 3-28. Total Number of Individual Riverine Sites Affected

Location	Montana	Nebraska		Iowa		Kansas		Missouri	
Levee status	No Levee	Behind Levees	No Levee	Behind Levees	No Levee	Behind Levees	No Levee	Behind Levees	No Levee
Alternatives 1, 3–5	5	24	126	121	54	4	21	196	939
Alternative 2	5	24	126	121	53	4	21	196	939
Alternative 6	5	24	134	121	54	4	21	196	939

Note: Neither North Dakota nor South Dakota had inventoried cultural resource sites in riverine settings of the study area that may be impacted.

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.

3.9.3.1 Impacts from Management Actions Common to all Alternatives

Fish rearing and stocking, predator management, and human restriction have little likelihood of directly impacting cultural resource sites, however, there may be concerns related to a Tribe or Tribal members access to locations for plant gathering and traditional practices (see Section 3.20, Tribal Interests (Other)). Ongoing consultation activities associated with site-specific actions would continue to seek to avoid or minimize these types of impacts.

Vegetation clearing for the construction and maintenance of emergent sandbar habitat could impact cultural resource sites in ways similar to mechanical construction. However, the most likely candidate locations for vegetation clearing would consist of recently deposited alluvial sandbars, which once provided habitat but became overgrown. Recent sediment deposits have low or no potential to contain cultural resource sites. In general there is lower risk to cultural resources from this management action, but NHPA Section 106 and 110 will be followed for site-specific actions based on NHPA Programmatic Agreements and consultations.

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

The amount of risk to cultural resource sites at a particular reservoir is a function of the number of sites at a particular reservoir and the amount, frequency, and duration of variation in reservoir pool level. Of the mainstem reservoirs, Lake Oahe had the greatest number of sites (for some years, up to 175 sites) that were normally submerged below the normal operating pool elevation but subject to risks of looting and erosion during low water periods. For one year in the modeled POR for Alternative 1, none of Lake Oahe sites would be exposed. Fort Peck Lake and Lewis and Clark Lake each have only a few known submerged sites that would be exposed during periods of low water under Alternative 1. Lake Sharpe consistently has approximately a dozen known sites exposed during low water periods, but the number is relatively stable from year to year. Lake Sakakawea and Lake Francis Case consistently have one dozen to three dozen sites exposed each year. Additionally, sites below normal pool elevations are often protected by sediment layers, and generally lower-elevation sites have deeper sediment layers offering greater levels of protection (Lenihan et al. 1981).

In general, on most reservoirs have a greater number of affected sites above maximum-normal pool level (as compared to the number of affected sites below minimum-normal pool level), but these sites would generally be affected less frequently and for shorter durations. Lenihan et al. (1981) noted that archaeological sites that were not inundated long enough to harm vegetation remain protected from erosion. The amount of protection provided depends on the species of vegetation, but most species of grass will begin to die off after approximately five days of high water.

Lake Oahe also has the largest number of sites normally located above maximum-normal pool elevation. In this case, however, for most years no known sites are exposed to greater-than-

normal risk of erosion. During the modeled 82-year POR, there were nine years with approximately 200 of Lake Oahe sites subject to greater-than-normal risk of erosion during high water periods, eight years with ten or fewer sites subject to greater-than-normal risk from high water, and 65 years with no sites subject to greater-than-normal water levels. Lake Sharpe has a greater number of site-days of impacts; however, the same numbers of sites are impacted for the same number of days every year over the entire modeled POR. This regularity suggests that these sites, despite being above the maximum-normal pool level, are close enough to the normal range of pool elevations to be routinely subject to risk of wave damage. Lewis and Clark Lake had between one and two dozen sites impacted by high water every year. Sites located above maximum-normal pool elevation at Fort Peck Lake, Lake Sakakawea, and Lake Francis Case would only be subject to greater-than-normal risk during major flood events.

Riverine sites (i.e., sites located in the Missouri River floodplain outside of federally managed lands on the mainstem reservoir system) may be impacted during flood events. No known cultural resources sites were impacted during the modeled POR in riverine settings of North Dakota or South Dakota. Screening efforts indicated that Montana had only five riverine sites that could be affected during the highest flood events. Under Alternative 1, some sites in Iowa, Nebraska, Kansas, and Missouri would be affected by high water from year to year, and many sites would be affected for weeks or months during large flood events. The model indicates that Missouri and Nebraska would have more site-days greater-than-normal risk (as compared to Iowa in Kansas), but this is in part due to the greater number of known sites in Missouri and Nebraska (as compared to Iowa and Kansas), particularly known sites that are not protected by levees.

Mechanical Habitat Construction

Alternative 1 includes an average of 107 acres of mechanical construction annually of ESH in the Gavins Point and Garrison Reaches. It also includes up to 3,999 acres of shallow water habitat construction in the lower river between Ponca, NE and the Mississippi River confluence. Any project that requires mechanical construction, ground disturbance, or earthmoving brings some risk to cultural resources either directly through damage to property during construction or indirectly in the form of increased risk of looting due to increased access or risks of erosion due to various possible changes, such as loss of protective vegetative cover or changes in or redirection of local flows. Due to the relatively small amount of habitat construction that would occur in the designated reaches, impacts would be small. There could be localized long-term adverse impacts to cultural resources if any properties are damaged during construction or if erosion causes damage from loss of protective vegetative cover or changes in or redirection of local flows. NHPA Section 106 and 110 will be followed for any individual habitat construction project, and implemented based on NHPA Programmatic Agreements and consultations.

Conclusion

Alternative 1 represents the continuation of current system operation and MRRP implementation. It primarily serves as a reference condition allowing for a comparison of the action alternatives. The analysis indicates some cultural resources sites would remain at risk under Alternative 1 due to fluctuations in the hydrologic and climatic cycles and the associated influence on river hydrology.

3.9.3.3 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 calls for comparatively high fluctuations in water levels on the reservoirs to support high flow releases for endangered species habitat creation and spring pallid sturgeon flow releases. As modeled, Alternative 2 flow releases would cause large fluctuations in water levels within the mainstem reservoirs of the alternatives. This fluctuation resulted in increases in frequency and duration of risks for erosion and looting at sites that were normally above normal operating pool levels.

As shown in Table 3-29, under Alternative 2 all reservoirs would have either an increase or negligible change in the average-annual site-days of greater-than-normal risk over the modeled POR (as compared with Alternative 1). With the exception of Lake Oahe, and Fort Peck Lake, all reservoirs also had either a slight increase or no change in the number of years impacts were observed in the modeled POR (as compared with Alternative 1). Lake Oahe had the greatest increase in total site-days of impacts observed on any reservoir for both sites located above maximum-normal pool elevation and sites located below minimum-normal pool elevation. In general, an increase in site-days of impacts on a given reservoir indicates an increase in duration and/or magnitude of impacts to sites. By percentage, Fort Peck Lake would have the greatest increase (relative to Alternative 1) in site-days of greater-than-normal risk for sites located above maximum-normal pool elevation, although a relatively small change in absolute terms.

As shown in Table 3-30, within the riverine reaches of the study area, Missouri would have the largest overall decrease in site-days of greater-than-normal, and Iowa would have the greatest overall increase in site-days of greater-than-normal risk under, as compared to Alternative 1.

Table 3-29. Change in Risk to Sites within the Mainstem Reservoir System for Alternative 2, Compared to Alternative 1 (Modeled over the POR)

Location		Average-Annual Site-Days of Greater-than-Normal Risk		Years impacts were observed over the POR	
		Alternative 1	Alternative 2	Alternative 1	Alternative 2
Fort Peck Lake	Above	17	26 (+53%)	2	3
	Below	322	328 (+2%)	66	64
Lake Sakakawea	Above	543	707 (+30%)	7	9
	Below	7,347	7,366 (+0%)	82	82
Lake Oahe	Above	1,560	1,775 (+14%)	17	16
	Below	29,962	30,703 (+2%)	81	82
Lake Sharpe	Above	2,922	2,921 (−0%)	82	82
	Below	4,748	4,749 (+0%)	82	82
Lake Francis Case	Above	351	401 (+14%)	13	15
	Below	3,572	3,587 (+0%)	82	82
Lewis and Clark Lake	Above	649	663 (+2%)	82	82
	Below	5	5 (0%)	51	56

Table 3-30. Change in Risk to Sites within Riverine Reaches for Alternative 2, Compared to Alternative 1 (Modeled over the POR)

State	Levee Status	Average-Annual Site-Days of Greater-than-Normal Risk		Years impacts were observed over the POR	
		Alternative 1	Alternative 2	Alternative 1	Alternative 2
Iowa	No Levee	267	286 (+7%)	71	77
	Behind Levees	149	150 (+1%)	13	14
Kansas	No Levee	25	25 (0%)	18	15
	Behind Levees	9	9 (0%)	19	20
Missouri	No Levee	4,478	4,462 (−0%)	82	82
	Behind Levees	553	511 (−8%)	47	47
Nebraska	No Levee	7,962	7,929 (−0%)	82	82
	Behind Levees	21	20 (−5%)	14	15
Montana	No Levee	1	1 (0%)	1	1

Notes: The values in parenthesis indicate percent difference between alternatives.

North Dakota and South Dakota have no known cultural resource sites impacted within the riverine sections under any alternatives. Montana has no known sites located behind levees that would be impacted.

Mechanical Habitat Construction

Alternative 2 includes 3,546 acres annually of mechanical construction of ESH in the Gavins Point, Lewis and Clark, Fort Randall, and Garrison Reaches. It also includes up to 10,758 acres of shallow water habitat construction in the lower river between Ponca, NE and the Mississippi River confluence. The type of risk to cultural resources under Alternative 2 are similar to those described under Alternative 1 and include impacts either directly through damage to property during construction or indirectly in the form of increased risk of looting due to increased access or risks of erosion due to various possible changes, such as loss of protective vegetative cover or changes in or redirection of local flows. However, the magnitude of the annual ESH construction required under Alternative 2 would be much larger than under Alternative 1 (3,546 acres annually vs. 107 acres annually) and would occur across a broader geographic area as construction would also occur in the Fort Randall and Lewis and Clark Reaches. This level of ESH construction under Alternative 2 is anticipated to have a greater risk of adverse construction-related impacts on cultural resources from direct damage to property and a high risk of erosion due to the large amount of loss of protective vegetative cover or changes in or redirection of local flows. Due to the greater amount of habitat construction that would occur in the designated reaches under Alternative 2 compared to Alternative 1, impacts could be large. There could be localized long-term adverse impacts to cultural resources if any properties are damaged during construction or if erosion causes damage from loss of protective vegetative cover or changes in or redirection of local flows. However, NHPA Section 106 and 110 would be followed for any individual habitat construction project, and implemented based on NHPA Programmatic Agreements and consultations.

Conclusion

Alternative 2 is expected to have large adverse impacts to cultural resources relative to the No Action Alternative. The majority of reservoirs would be subject to an increase in total site-days of greater-than-normal risk. Under Alternative 2, cultural resource sites in Missouri would be

subject to a slight decrease in risk, sites in Nebraska would be subject to a slight increase in risk, and sites in Iowa and Kansas would be subject to negligible change in risk. Given the increase in total site-days of greater-than-normal risk across the majority of reservoirs significant impacts to cultural sites could occur under Alternative 2 relative to Alternative 1.

3.9.3.4 Alternative 3 – Mechanical Construction Only

Analysis of the Alternative 3 indicated very little change to flows when compared to Alternative 1. The greatest increase in risk would be for sites located above maximum-normal pool elevations at Lake Sakakawea and Lake Francis Case. This results from slightly longer periods in which these reservoirs remain at higher than normal water elevations, as compared to Alternative 1. Alternative 3 would also result in no substantial downstream changes in impacts to cultural resource sites from flows, as compared to Alternative 1. Changes in risk for cultural resources sites in riverine reaches of the study area would be small or negligible. Outside of flow modifications, the Alternative 3 has the potential to have greater risk of both direct and indirect impacts to cultural resources through increased ESH construction, as compared with Alternative 1 (Table 3-31 and Table 3-32).

Table 3-31. Change in Risk to Sites within the Mainstem Reservoir System for Alternative 3, Compared to Alternative 1 (Modeled over the POR)

Location		Average-Annual Site-Days of Greater-than-Normal Risk		Years impacts were observed over the POR	
		Alternative 1	Alternative 3	Alternative 1	Alternative 3
Fort Peck Lake	Above	17	17 (0%)	2	2
	Below	322	321 (-0%)	66	66
Lake Sakakawea	Above	543	573 (+6%)	7	7
	Below	7,347	7,332 (−0%)	82	82
Lake Oahe	Above	1,560	1,541 (−1%)	17	17
	Below	29,962	29,863 (-0%)	81	81
Lake Sharpe	Above	2,922	2,922 (0%)	82	82
	Below	4,748	4,748 (0%)	82	82
Lake Francis Case	Above	351	375 (+7%)	13	13
	Below	3,572	3,574 (+0%)	82	82
Lewis and Clark Lake	Above	649	652 (+0%)	82	82
	Below	5	5 (0%)	51	46

Table 3-32. Change in Risk to Sites within Riverine Reaches for Alternative 3, Compared to Alternative 1 (Modeled over the POR)

State	Levee Status	Average-Annual Site-Days of Greater-than-Normal Risk		Years impacts were observed over the POR	
		Alternative 1	Alternative 3	Alternative 1	Alternative 3
Iowa	No Levee	267	268 (0%)	71	71
	Behind Levees	149	149 (0%)	13	13
Kansas	No Levee	25	25 (0%)	18	15
	Behind Levees	9	9 (0%)	19	19
Missouri	No Levee	4,478	4,479 (+0%)	82	82
	Behind Levees	553	537 (−3%)	47	47
Nebraska	No Levee	7,962	7,970 (+0%)	82	82
	Behind Levees	21	21 (0%)	14	14
Montana	No Levee	1	1 (0%)	1	1

Notes: The values in parenthesis indicate percent difference between alternatives.

North Dakota and South Dakota have no known cultural resource sites impacted within the riverine sections under any alternatives. Montana has no known sites located behind levees that would be impacted.

Mechanical Habitat Construction

Alternative 3 includes an average of 391 acres of annual ESH construction in the Gavins Point, Fort Randall, and Garrison Reaches in years where construction occurs. It also includes up to 3,380 acres of IRC construction in the lower river between Ponca, NE and the Mississippi River confluence. The risks to cultural resource sites under Alternative 3 are similar to those described under Alternative 1. These risks include potential impacts directly through damage to property during construction and potential indirect impacts in the form of looting (resulting from increased access to sites) or erosion due to loss of protective vegetative cover or changes in or redirection of local flows. However, compared to Alternative 1, these risks would occur across a broader geographic area under Alternative 3, as construction would also occur in the Fort Randall reach. The difference in the amount of acres of mechanical habitat construction under Alternative 3 (as compared to Alternative 1) is small, and therefore, impacts would be negligible compared to Alternative 1.

There could be localized long-term adverse impacts to cultural resources if any properties are damaged during construction or if erosion causes damage from loss of protective vegetative cover or changes in or redirection of local flows. NHPA Section 106 and 110 will be followed for any individual habitat construction project, and implemented based on NHPA Programmatic Agreements and consultations.

Conclusion

The analysis indicates slight increases in risk to sites at Lake Francis Case and Lake Sakakawea, and no change or very slight decreases in risk for sites in other geographic areas. Alternative 3 would result in small changes in risk to cultural resource sites relative to the No

Action and is therefore not anticipated to cause significant impacts to cultural resources relative to Alternative 1.

3.9.3.5 Alternative 4 – Spring ESH Creating Release

Analysis of Alternative 4 showed large changes to impacts on cultural resource sites compared to Alternative 1. Relative to Alternative 1, sites on Lake Sakakawea would be subject to an increase in risk as would sites located below minimum-normal pool elevation at Lake Oahe and Fort Peck Lake. Sites located in the riverine reaches in Iowa would have increases in site-days of greater-than-normal risk, as compared with Alternative 1. Sites at other locations would be subject to either no changes or small decreases in risk compared to the Alternative 1 (Table 3-33 and Table 3-34).

Table 3-33. Change in Risk to Sites within the Mainstem Reservoir System for Alternative 4, Compared to Alternative 1 (Modeled over the POR)

Location		Average-Annual Site-Days of Greater-than-Normal Risk		Years impacts were observed over the POR	
		Alternative 1	Alternative 4	Alternative 1	Alternative 4
Fort Peck Lake	Above	17	16 (−6%)	2	2
	Below	322	349 (+8%)	66	66
Lake Sakakawea	Above	543	559 (+3%)	7	6
	Below	7,347	7,694 (+5%)	82	82
Lake Oahe	Above	1,560	1,432 (−8%)	17	16
	Below	29,962	31,495 (+5%)	81	81
Lake Sharpe	Above	2,922	2,922 (0%)	82	82
	Below	4,748	4,748 (0%)	82	82
Lake Francis Case	Above	351	343 (−2%)	13	13
	Below	3,572	3,578 (+0%)	82	82
Lewis and Clark Lake	Above	649	652 (+0%)	82	82
	Below	5	5 (0%)	51	54

Table 3-34. Change in Risk to Sites within Riverine Reaches for Alternative 4, Compared to Alternative 1 (Modeled over the POR)

State	Levee Status	Average-Annual Site-Days of Greater-than-Normal Risk		Years impacts were observed over the POR	
		Alternative 1	Alternative 4	Alternative 1	Alternative 4
Iowa	No Levee	267	285 (+7%)	71	74
	Behind Levees	149	147 (−1%)	13	13
Kansas	No Levee	25	25 (0%)	18	15
	Behind Levees	9	8 (−11%)	19	18

State	Levee Status	Average-Annual Site-Days of Greater-than-Normal Risk		Years impacts were observed over the POR	
		Alternative 1	Alternative 4	Alternative 1	Alternative 4
Missouri	No Levee	4,478	4,493 (+0%)	82	82
	Behind Levees	553	535 (−3%)	47	47
Nebraska	No Levee	7,962	7,973 (+0%)	82	82
	Behind Levees	21	21 (0%)	14	14
Montana	No Levee	1	1 (0%)	1	1

Notes: The values in parenthesis indicate percent difference between alternatives.

North Dakota and South Dakota have no known cultural resource sites impacted within the riverine sections under any alternatives. Montana has no known sites located behind levees that would be impacted.

Mechanical Habitat Construction

Alternative 4 includes an average of 240 acres of annual ESH construction in the Gavins Point, Fort Randall, and Garrison Reaches in years where construction occurs. It also includes up to 3,380 acres of shallow water habitat construction in the lower river between Ponca, NE and the Mississippi River confluence. The risk to cultural resources under Alternative 4 is similar to those described under Alternative 1. These risks include potential impacts directly through damage to property during construction and potential indirect impacts in the form of looting (resulting from increased access to sites) or erosion due to loss of protective vegetative cover or changes in or redirection of local flows. However, compared to Alternative 1, these risks would occur across a broader geographic area under Alternative 4, as construction would also occur in the Fort Randall reach. There could be localized long-term adverse impacts to cultural resources if any properties are damaged during construction or if erosion causes damage from loss of protective vegetative cover or changes in or redirection of local flows. The difference in the amount of acres of mechanical habitat construction under Alternative 4 compared to Alternative 1 is small, and therefore, impacts would be negligible compared to Alternative 1. NHPA Section 106 and 110 will be followed for any individual habitat construction project, and implemented based on NHPA Programmatic Agreements and consultations.

Conclusion

Alternative 4 is expected to have large adverse impacts to cultural resources at Lake Oahe relative to Alternative 1. The analysis also indicated some minor increases in risk under Alternative 4 for sites at Lake Sakakawea, Fort Peck Lake, and sites at riverine settings in Iowa. Alternative 4 has the potential to have variable impacts on cultural resource sites located within the mainstem reservoir system however, these impacts would be small, relative to Alternative 1, except at Lake Oahe. Given the large increase in adverse impacts to cultural resources at Lake Oahe, significant impacts could occur under Alternative 4 relative to Alternative 1.

3.9.3.6 Alternative 5 – Fall ESH Creating Release

Analysis of Alternative 5 showed variable changes to impacts on cultural resource sites compared to Alternative 1. The analysis generally showed decreased risk for reservoir sites

located above maximum-normal pool elevations, but increased risk for sites located below minimum-normal pool elevations. Cultural resource sites in riverine reaches, however, had no change or small changes in site-days of greater-than-normal risk (Table 3-35 and Table 3-36).

Table 3-35. Change in Risk to Sites within the Mainstem Reservoir System for Alternative 5, Compared to Alternative 1 (Modeled over the POR)

Location		Average-Annual Site-Days of Greater-than-Normal Risk		Years impacts were observed over the POR	
		Alternative 1	Alternative 5	Alternative 1	Alternative 5
Fort Peck Lake	Above	17	14 (−18%)	2	2
	Below	322	331 (+3%)	66	68
Lake Sakakawea	Above	543	495 (−9%)	7	6
	Below	7,347	7,640 (+4%)	82	82
Lake Oahe	Above	1,560	1,262 (−19%)	17	17
	Below	29,962	30,354 (+1%)	81	82
Lake Sharpe	Above	2,922	2,922 (0%)	82	82
	Below	4,748	4,748 (0%)	82	82
Lake Francis Case	Above	351	303 (−14%)	13	13
	Below	3,572	3,576 (+0%)	82	82
Lewis and Clark Lake	Above	649	644 (−1%)	82	82
	Below	5	5 (0%)	51	50

Table 3-36. Change in Risk to Sites within Riverine Reaches for Alternative 5, Compared to Alternative 1 (Modeled over the POR)

State	Levee Status	Average-Annual Site-Days of Greater-than-Normal Risk		Years impacts were observed over the POR	
		Alternative 1	Alternative 5	Alternative 1	Alternative 5
Iowa	No Levee	267	275 (+3%)	71	71
	Behind Levees	149	148 (−0%)	13	13
Kansas	No Levee	25	25 (0%)	18	15
	Behind Levees	9	9 (0%)	19	19
Missouri	No Levee	4,478	4,470 (−0%)	82	82
	Behind Levees	553	536 (−3%)	47	47
Nebraska	No Levee	7,962	7,968 (+0%)	82	82
	Behind Levees	21	21 (0%)	14	14
Montana	No Levee	1	1 (0%)	1	1

Notes: The values in parenthesis indicate percent difference between alternatives.

North Dakota and South Dakota have no known cultural resource sites impacted within the riverine sections under any alternatives. Montana has no known sites located behind levees that would be impacted.

Mechanical Habitat Construction

Alternative 5 includes an average of 309 acres annually of mechanical construction of ESH in the Gavins Point, Fort Randall, and Garrison Reaches in years where construction occurs. It also includes up to 3,380 acres of shallow water habitat construction in the lower river between Ponca, NE and the Mississippi River confluence. The risk to cultural resources under Alternative 5 is similar to those described under Alternative 1. These risks include potential impacts directly through damage to property during construction and potential indirect impacts in the form of looting (resulting from increased access to sites) or erosion due to loss of protective vegetative cover or changes in or redirection of local flows. However, compared to Alternative 1, these risks would occur across a broader geographic area under Alternative 5, as construction would also occur in the Fort Randall reach. The difference in the amount of acres of mechanical habitat construction under Alternative 5 compared to Alternative 1 is small, and therefore, impacts would be negligible compared to Alternative 1. There could be localized long-term adverse impacts to cultural resources if any properties are damaged during construction or if erosion causes damage from loss of protective vegetative cover or changes in or redirection of local flows. NHPA Section 106 and 110 would be followed for any individual habitat construction project, and implemented based on NHPA Programmatic Agreements and consultations.

Conclusion

Alternative 5 shows a small overall change to risk for cultural resources sites at reservoir settings, as compared to the Alternative 1. In reservoir settings, the analysis showed increases in risk to cultural resources sites located below minimum-normal pool elevations at Lake Sakakawea, Fort Peck Lake, and Lake Oahe, but decreases in risk for sites above maximum-normal pool elevations at all reservoirs except Lake Sharpe. Alternative 5 shows a negligible change for sites in riverine settings, as compared to the Alternative 1. Alternative 5 is not anticipated to have significant impacts to cultural resources for these reasons.

3.9.3.7 Alternative 6 – Pallid Sturgeon Spawning Cue

Analysis of Alternative 6 indicated Fort Peck Lake and Lake Sakakawea, as well as the riverine reaches in Iowa, would have small increases in site-days greater-than-normal risk, relative to Alternative 1. Lake Oahe, however, would be subject to a larger increase in site-days of greater-than-normal risk (relative to Alternative 1), particularly for sites located below minimum-normal pool elevation. Lake Francis Case, Lewis and Clark Lake, Kansas, Missouri, and Iowa would be subject to small decreases in risk (Table 3-37 and Table 3-38).

Table 3-37. Change in Risk to Sites within the Mainstem Reservoir System for Alternative 6, Compared to Alternative 1 (Modeled over the POR)

Location		Average-Annual Site-Days of Greater-than-Normal Risk		Years impacts were observed over the POR	
		Alternative 1	Alternative 6	Alternative 1	Alternative 6
Fort Peck Lake	Above	17	17 (0%)	2	2
	Below	322	336 (+4%)	66	66
Lake Sakakawea	Above	543	565 (+4%)	7	6
	Below	7,347	7,551 (+3%)	82	82

Location		Average-Annual Site-Days of Greater-than-Normal Risk		Years impacts were observed over the POR	
		Alternative 1	Alternative 6	Alternative 1	Alternative 6
Lake Oahe	Above	1,560	1,460 (−6%)	17	17
	Below	29,962	31,432 (+5%)	81	81
Lake Sharpe	Above	2,922	2,921 (−0%)	82	82
	Below	4,748	4,749 (+0%)	82	82
Lake Francis Case	Above	351	355 (+1%)	13	13
	Below	3,572	3,577 (+0%)	82	82
Lewis and Clark Lake	Above	649	648 (−0%)	82	82
	Below	5	5 (0%)	51	54

Table 3-38. Change in Risk to Sites within Riverine Reaches for Alternative 6, Compared to Alternative 1 (Modeled over the POR)

State	Levee Status	Average-Annual Site-Days of Greater-than-Normal Risk		Years impacts were observed over the POR	
		Alternative 1	Alternative 6	Alternative 1	Alternative 6
Iowa	No Levee	267	281 (+5%)	71	76
	Behind Levees	149	149 (0%)	13	13
Kansas	No Levee	25	25 (0%)	18	16
	Behind Levees	9	9 (0%)	19	18
Missouri	No Levee	4,478	4,489 (+0%)	82	82
	Behind Levees	553	537 (−3%)	47	47
Nebraska	No Levee	7,962	7,967 (+0%)	82	82
	Behind Levees	21	21 (0%)	14	14
Montana	No Levee	1	1 (0%)	1	1

Notes: The values in parenthesis indicate percent difference between alternatives.

North Dakota and South Dakota have no known cultural resource sites impacted within the riverine sections under any alternatives. Montana has no known sites located behind levees that would be impacted.

Mechanical Habitat Construction

Alternative 6 includes an average of 303 acres of annual ESH construction in the Gavins Point, Fort Randall, and Garrison Reaches in years where construction occurs. It also includes up to 3,380 acres of shallow water habitat construction in the lower river between Ponca, NE and the Mississippi River confluence. The risk to cultural resources under Alternative 6 is similar to those described under Alternative 1. These risks include potential impacts directly through damage to property during construction and potential indirect impacts in the form of looting (resulting from increased access to sites) or erosion due to loss of protective vegetative cover or changes in or redirection of local flows. However, compared to Alternative 1, these risks would occur across a broader geographic area under Alternative 6, as construction would also occur in

the Fort Randall reach. The difference in the amount of acres of mechanical habitat construction under Alternative 6 compared to Alternative 1 is small, and therefore, impacts would be negligible compared to Alternative 1. There could be localized long-term adverse impacts to cultural resources if any properties are damaged during construction or if erosion causes damage from loss of protective vegetative cover or changes in or redirection of local flows. NHPA Section 106 and 110 will be followed for any individual habitat construction project, and implemented based on NHPA Programmatic Agreements and consultations.

Conclusion

Alternative 6 is expected to have large adverse impacts to cultural resources (relative to the Alternative 1) at Lake Oahe. The analysis also indicated some minor increases in risk under Alternative 6 for sites at Lake Sakakawea, Fort Peck Lake, and sites at riverine settings in Iowa. Alternative 6 has the potential to have variable impacts on cultural resource sites located within the mainstem reservoir system; however, these impacts would be small, relative to Alternative 1, except at Lake Oahe. Significant impacts could occur under Alternative 6 due to large adverse impacts at Lake Oahe relative to Alternative 1.

3.9.3.8 Climate Change

The Climate Change scenarios presented in the “Climate Change Assessment – Missouri River Basin” (available online at www.moriverrecovery.org), indicate higher temperatures in the basin, increased precipitation, greater variability in the timing of precipitation with greater rainfall in the spring and earlier spring snowmelt, decreased snowmelt season duration, and decreased peak snowmelt flows. Extremes in climate will likely also magnify periods of wet or dry weather, resulting in longer, more severe droughts, and larger more extensive flooding. Likely impacts to cultural resources would follow from increases to variability of reservoir water surface elevations, and greater flood related damages in riverine settings. However, it is assumed that the conclusions described would be similar under each alternative.

3.9.3.9 Cumulative Impacts

Past, present, and reasonably foreseeable future actions have adversely affected cultural resources within the floodplain and mainstem reservoir system. Impacts to cultural resources can result directly from changes in water levels or changes to river channels resulting in increased erosion from fluctuating water levels, or changes in existing land use and ownership, as well as agriculture, oil and gas development, urban and infrastructure development, and associated policy changes. Actions that would affect bed degradation also would impact cultural resources as degradation results in increases in erosion and exposure of cultural resource sites within the floodplain and along tributaries, which can damage cultural resources. Ongoing development on lands within the floodplain, including oil and gas development, transportation and utility corridor development, can directly impact cultural resources through direct construction related impacts to a historic property in terms of its integrity and condition, or indirectly from changes to the historic sense and feel of the location and/or increased access to the property resulting in increased risk of looting and vandalism. The impacts from other past, present, and reasonably foreseeable actions would be similar across all of the alternatives (1–6). The contribution to impacts from Alternatives 2–6, when compared to Alternative 1, is negligible to small.

Under alternative 1, construction of shallow water habitat, and sandbar habitat would continue. Construction actions have the potential to cause adverse impacts to cultural resource sites;

however, as with all of the alternatives, planning actions for these projects would seek to avoid impacts to any cultural resources that are present. Additionally, federal acquisition of property for the purposes of habitat restoration and construction could have beneficial impacts through preservation and regulation otherwise unavailable to the resource. When combined with past, present, and reasonably foreseeable future actions, cumulative impacts under Alternative 1 would be long term and adverse. The contribution of Alternative 1 to the adverse cumulative impacts would be negligible. Although the federal acquisition of lands would result in some increase in the protection and management of cultural resources sites located on land acquired for habitat restoration, the contribution would be negligible in comparison to the larger actions and activities related to the use of the Missouri River System.

Under Alternative 2, the variable flow releases may cause increases in impacts from erosion and exposure to cultural resource sites located along reservoir shorelines from fluctuating water levels. Additionally, this alternative calls for more acres of mechanical construction than Alternative 1. There is an increased chance of disturbing cultural resource sites under this alternative given the higher amounts of construction activities and variable flow releases. As with Alternative 1, the federal acquisition of property for the purposes of habitat restoration and construction could have beneficial impacts through preservation and regulation otherwise unavailable to the resource. When combined with past, present, and reasonably foreseeable future actions, cumulative impacts under Alternative 2 would be long term and adverse. The contribution to adverse impacts from Alternative 2 in context of other past, present, and reasonably foreseeable future actions is anticipated to be small.

Alternative 3 would result in increased ESH creation and associated construction that could adversely impact cultural resource sites. As with Alternative 1, the federal acquisition of property for the purposes of habitat restoration and construction could have beneficial impacts through preservation and regulation otherwise unavailable to the resource. When combined with past, present, and reasonably foreseeable future actions, cumulative impacts under Alternative 3 would be long term and adverse, but the contribution to adverse cumulative impacts from this alternative would be negligible given site-specific analysis and coordination that would occur.

Alternative 4 would result in the potential for fewer adverse impacts to cultural resource sites from construction, but variation in flows that would adversely impact individual cultural resource sites due to increased frequency and magnitude of reservoir average surface level fluctuations. When combined with past, present, and reasonably foreseeable future actions, cumulative impacts under Alternative 4 would be long-term and adverse. The contribution to adverse impacts from Alternative 4 in context of other past, present, and reasonably foreseeable future actions is anticipated to be small.

Alternative 5 releases would occur in the fall rather than the spring. When combined with past, present, and reasonably foreseeable future actions, cumulative impacts under Alternative 5 would be long term and adverse. The contribution to adverse impacts from Alternative 5 in context of other past, present, and reasonably foreseeable future actions is anticipated to be small. The analysis forecasted an increased chance of risk to cultural resources for some reservoirs, particularly Lewis and Clark Lake.

The variable flow releases under Alternative 6 may cause increases in impacts from erosion and exposure to cultural resource sites located along reservoir shorelines from fluctuating water levels. The contribution to adverse impacts from Alternative 6 in context of other past, present, and reasonably foreseeable future actions is small given site-specific analysis and coordination that would occur.

3.10 Land Use and Ownership

3.10.1 Affected Environment

Land use refers to the human use of land along the Missouri River and its floodplain. As such, this section describes land use patterns and ownership generally for the floodplain area along the Missouri River. This section focuses on agriculture because it is a dominant land use in the floodplain.

3.10.1.1 Land Use Patterns

Land use patterns within the floodplain include developed lands, agricultural lands, open water, and other land use types. Developed lands refer to communities, towns, and cities including commercial, industrial, residential, transportation (highways, roads, bridges, railroads), and infrastructure property located in the Missouri River floodplain. Agricultural land use consists of non-developed areas including croplands, grazing, and ranching lands.

Land use patterns for the floodplain area were interpreted through geospatial analysis based on available land cover data from the National Agricultural Statistics Service (NASS) 2014 Cropland Data Layer. The land use patterns within the river reaches are summarized in Table 3-39. Land cover types were grouped into four categories for this discussion: (1) open water, (2) agriculture, (3) developed, and (4) forests, wetlands, grasslands, and shrublands. Agricultural land cover types include cultivated crops, pasture, hay, alfalfa, fallow lands, and idle croplands. Developed lands include developed open space and developed low, medium, and high intensity lands.

Table 3-39. Land Cover Acres as Percent of Missouri River Floodplain

River Reach	Open Water	Agriculture	Developed	Forests, Wetlands, Grasslands, and Shrublands[a]	Total Acres within Floodplain[b]
Fort Peck Lake	80.5%	0.6%	0.0%	18.9%	215,424
Fort Peck Dam to Lake Sakakawea	9.5%	55.3%	3.8%	31.4%	228,201
Lake Sakakawea	77.1%	8.3%	1.3%	13.3%	314,715
Garrison Dam to Lake Oahe	17.1%	31.6%	3.6%	47.7%	72,497
Lake Oahe	81.3%	3.6%	2.6%	12.5%	295,935
Oahe Dam to Lake Sharpe	29.6%	9.1%	25.2%	36.0%	5,645
Lake Sharpe	77.3%	8.6%	3.3%	10.8%	72,905
Lake Francis Case	95.7%	0.4%	0.5%	3.4%	81,084
Fort Randall Dam to Lewis and Clark Lake	37.8%	30.8%	3.0%	28.4%	32,281

River Reach	Open Water	Agriculture	Developed	Forests, Wetlands, Grasslands, and Shrublands[a]	Total Acres within Floodplain[b]
Lewis and Clark Lake	81.1%	1.0%	1.3%	16.6%	32,281
Gavins Point Dam to Rulo	5.0%	71.6%	9.1%	14.3%	1,355,292
Rulo to the Mouth of the Missouri River	10.5%	63.2%	8.3%	18.0%	887,403
Total Acres/Percent	**28.5%**	**48.3%**	**6.3%**	**16.9%**	**3,593,663**

Source: USDA NASS, Cropland Data Layer 2014

a Forests, wetlands, grasslands, and shrublands also include the barren lands and herbaceous grassland land covers.

b Total floodplain acreages are estimates derived from geographic computations of pixilated 30-meter square representations of land cover.

Agriculture is the dominant land use in the floodplain between Gavins Point Dam and the mouth of the Missouri River, accounting for 63 to 72 percent of floodplain land. Open water occupies a high percentage of land cover within the six mainstem reservoirs including Fort Peck Lake, Lake Sakakawea, Lake Oahe, Lake Sharpe, Lake Francis Case, and Lewis and Clark Lake. Forests, wetlands, grasslands, and shrublands account for a varying amount of the floodplain across all river reaches and reservoirs, with the highest percentages occurring from Oahe Dam to Lake Sharpe (36 percent) and from Fort Randall Dam to Lewis and Clark Lake (28 percent).

3.10.1.2 Land Ownership

Land ownership refers to the type of agency or entity owning and typically managing land parcels within the river or reservoir reaches. Federal, state, and local agencies, Tribes, or private citizens can own and manage lands. Land ownership information is important as it affects the tax base for local governments. Property taxes paid to local governments are levied on the value of the property and its agricultural production, and changes in land ownership from private to public can affect the property tax revenues earned from these lands. The federal government does not pay property taxes on land it owns; therefore, when lands are purchased and put into federal ownership, property tax revenue on that land is not collected by the local government. However, payments in lieu of taxes (PILT) are payments made by the federal government to local governments that help offset losses in property taxes due to non-taxable federal lands within their boundaries.

Along the Missouri River, there are lands owned by federal, state, and local governments as well as Tribes and private land owners that are managed for conservation and recreation. Federal conservation lands and lands managed for natural habitats and recreation include those administered under the USACE MRRP, U.S. National Park Service (NPS) lands, and USFWS National Wildlife Refuge (NWR) lands, among others. There are also state and local government-owned lands managed for conservation within the floodplain. Data from the Protected Areas Database of the United States (PAD-US), which is published by the USGS Gap Analysis Program, includes an inventory of federal and non-federal conservation and protected

lands dedicated to the preservation of biological diversity and to other natural, recreational, and cultural uses, and managed for these purposes through legal or other effective means.[2]

Table 3-40 presents the acreage of these protected federal, state, and locally owned lands, as well as Tribal and other lands (i.e., private or non-governmental organization owner) in the floodplain by river reach, based on data from the PAD-US. USACE ownership and management of the reservoirs account for large amounts of federal land ownership in the upper basin. Tribal lands in the floodplain occur in the Fort Peck Dam to Lake Sakakawea and Fort Randall Dam to Lewis and Clark Lake river reach, as well as in Lake Sakakawea, Lake Oahe, Lake Sharpe, and Lake Francis Case. The highest proportion of state-owned floodplain lands occurs at Lewis and Clark Lake and in the river reach from Oahe Dam to Lake Sharpe.

Table 3-40. Protected Federal, State, and Native American Lands, and Other Conservation and Recreation Lands in the Floodplain, 2012

River Reach	Total Floodplain Acres	Total Protected Acres [a]	Land Ownership				
			Federal	Tribal	State	Local Government	Other Entities [b]
Fort Peck Lake	215,424	192,227	191,878	0	0	0	349
(% of floodplain)	100%	89.2%	89.1%	0.0%	0.0%	0.0%	0.2%
Fort Peck Dam to Lake Sakakawea	228,201	114,345	4,023	105,239	4,506	0	578
(% of floodplain)	100%	50.1%	1.8%	46.1%	2.0%	0.0%	0.3%
Lake Sakakawea	314,715	269,518	246,087	159	21,508	0	1,764
(% of floodplain)	100%	85.6%	78.2%	0.1%	6.8%	0.0%	0.6%
Garrison Dam to Lake Oahe	72,497	6,613	1,597	0	3,248	0	1,769
(% of floodplain)	100%	9.1%	2.2%	0.0%	4.5%	0.0%	2.4%
Lake Oahe	295,935	268,335	245,747	5,198	16,921	0	469
(% of floodplain)	100%	90.7%	83.0%	1.8%	5.7%	0.0%	0.2%
Oahe Dam to Lake Sharpe	5,645	2,403	1,969	0	434	0	0
(% of floodplain)	100%	42.6%	34.9%	0.0%	7.7%	0.0%	0.0%
Lake Sharpe	72,905	55,518	44,040	8,511	2,966	0	0
(% of floodplain)	100%	76.2%	60.4%	11.7%	4.1%	0.0%	0.0%
Lake Francis Case	81,084	71,484	70,794	248	441	0	0
(% of floodplain)	100%	88.2%	87.3%	0.3%	0.5%	0.0%	0.0%
Fort Randall Dam to Lewis and Clark Lake	32,281	28,162	18,570	8,230	219	0	1,143
(% of floodplain)	100%	87.2%	57.5%	25.5%	0.7%	0.0%	3.5%

[2] The PAD-US dataset is administered by the USGS and includes data from counties, cities, federal agencies, states, and national non-profit organizations. Additional information on PAD-US data can be found at the website: http://gapanalysis.usgs.gov/padus/data/.

River Reach	Total Floodplain Acres	Total Protected Acres [a]	Land Ownership				
			Federal	Tribal	State	Local Government	Other Entities [b]
Lewis and Clark Lake	39,401	34,788	23,299	3	11,456	0	30
(% of floodplain)	100%	88.3%	59.1%	0.0%	29.1%	0.0%	0.1%
Gavins Point Dam to Rulo	1,355,292	139,898	58,482	14,418	36,156	0	30,843
(% of floodplain)	100%	10.3%	4.3%	1.1%	2.7%	0.0%	2.3%
Rulo to the Mouth of the Missouri River	887,403	91,456	16,586	140	38,510	678	35,541
(% of floodplain)	100%	10.3%	1.9%	0.0%	4.3%	0.1%	4.0%

Source: PAD-US 2012

a The difference in acreage between the total floodplain and that portion of the floodplain that is identified as "protected" is accounted for in large measure by the existence of privately owned lands that do not contain conversation easements or other protected status.

b Other entities" may include non-governmental organizations or private land owners with conservation easements or other agreements that provide for protected land status.

3.10.1.3 Agriculture

Agriculture is the dominant land use within the floodplain. Of the nearly 3.6 million acres considered to be within the Missouri River floodplain, approximately 1.7 million acres, or 48 percent of the floodplain, is currently used for agricultural purposes (Table 3-39). This section describes the prevalence of crop and agricultural land covers within the Missouri River floodplain. While this section focuses on the types of crops within the floodplain, irrigated farmlands and interior drainage patterns are described in more detail in Section 3.12, Flood Risk Management and Interior Drainage and Section 3.14, Irrigation.[3]

Among agricultural lands, it is important to consider the crop types that are present in the floodplain. Missouri has the greatest number of agricultural acres in the Missouri River floodplain, with approximately 679,000 acres (Table 3-41). Kansas has the fewest agricultural acres, with only 25,000 acres in the floodplain. Corn and soybeans are the most common crops in the lower river states (Iowa, Missouri, Kansas, and Nebraska), while spring wheat and alfalfa are slightly more prevalent in states located in the upper river (North Dakota, South Dakota, Montana).

[3] Additionally, the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) administers the conservation programs as well as technical and financial assistance programs to improve natural resources. For example, farmers can elect to enroll lands in conservation program and activities, receiving payments for managing lands in the short or long-term for conservation and habitat. Conservation payments reimburse participating producers for all or part of the cost of implementing conservation practices. Additional information is available at the following websites: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/ and http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/.

Table 3-41. Percent of Agriculture Acreage by Crop in the Missouri River Floodplain by State

State	Total Flood-plain Acres	Total Agricul-tural Acres	Percentage of Floodplain Acres in Agriculture	Crop Type, as a percent of total floodplain acres							
				Corn	Soybeans	Spring Wheat	Alfalfa	Barley	Other Hay/ Non-Alfalfa	Fallow/ Idle Cropland	All Other Crops
Montana	417,081	125,124	30.0%	0.8%	0.5%	12.3%	5.0%	1.2%	5.1%	2.2%	2.9%
North Dakota	502,995	60,360	12.0%	2.7%	2.1%	2.9%	0.6%	0.5%	0.8%	0.2%	2.2%
South Dakota	617,520	196,371	31.8%	15.2%	13.4%	0.0%	1.8%	0.0%	0.7%	0.0%	0.7%
Nebraska	373,017	218,961	58.7%	31.8%	25.0%	0.0%	1.0%	0.0%	0.2%	0.0%	0.7%
Iowa	629,244	460,607	73.2%	39.2%	33.2%	0.0%	0.3%	0.0%	0.0%	0.0%	0.5%
Missouri	1,018,700	678,454	66.6%	29.2%	35.4%	0.0%	0.0%	0.0%	0.4%	0.0%	1.6%
Kansas	54,819	25,381	46.3%	23.2%	22.4%	0.0%	0.0%	0.0%	0.2%	0.1%	0.4%

Source: USDA NASS Cropland Data Layer 2014 (% of agricultural acreage by crop)

Note: Total floodplain acreages are estimates derived from geographic computations of pixilated 30-meter square representations of land cover.

3.10.2 Environmental Consequences

3.10.2.1 Impacts Assessment Methodology

Changes in land use and ownership could alter agricultural operations and crop production. Changes in agricultural activity could have regional effects that include changes in farm employment, implications for businesses that support farming operations, property tax receipts to local governments, and other effects due to farming households and other farm-related entities spending more or less money in the local and/or regional economy.

A change in land ownership from private to public would have an impact on property tax revenues earned from these lands. If lands were purchased by USACE and put into federal or state management, the property tax revenue to local governments would decrease. However, these local governments would be eligible for PILT payments to help offset losses in property taxes due to non-taxable federal lands within their boundaries.[4] In addition, once USACE acquires the land, USACE may spend a few years planning the project before starting construction at the site. In these cases, the land may be leased to private parties, usually for a term of 3 to 5 years, for agricultural use. In the State of Missouri, the U.S. government returns 75 percent of agricultural lease revenues to the county government to fund local services. This program can temporarily help with the shortfall of lost property taxes over and above the PILT payment, but leased acreages will be reduced as habitat development is put into place (USACE 2013). In Kansas, Nebraska, and Iowa, agricultural lease revenues are required to be used on the land for site development and therefore are not available to fund local services.

The impacts as a result of the federal government acquiring lands to construct pallid sturgeon early life stage habitat are evaluated using two of the four planning accounts: RED and OSE. The project implementation costs fully account for NED costs of acquiring lands and are, thus, not considered here. This section provides a brief overview of the overall methodology for evaluating the RED and OSE impacts as a result of the federal acquisition of lands for construction of early life stage habitat for the pallid sturgeon to meet the specified acreages under each of the MRRMP-EIS alternatives.

The No Action Alternative is considered the baseline against which the other alternatives are measured. Under the No Action Alternative, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, the No Action Alternative does 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.

Regional Economic Development

Two models were developed for the RED analysis and were used to evaluate impacts for all alternatives, including Alternative 1 (the No Action alternative). The analysis of Alternative 1 considers the targeted acreage that would be acquired under the existing MRRP but does not include any acreage that has already been acquired as part of this program. The analysis then compared the results calculated for Alternative 1 with those calculated for each of the action alternatives focusing on the change in jobs and income associated with additional target acres for land acquisition to support the development of habitat. Both models used data based on

[4] The PILT program is managed through the Bureau of Land Management, and payments are made through the U.S. Department of the Treasury. More information on the PILT program is available here: www.doi.gov/pilt/.

USACE assumptions for habitat creation under the draft MRRMP-EIS alternatives over the 15-year implementation period.

The estimated acres for federal acquisition of lands for the pallid sturgeon habitat construction are shown in Chapter 2.0. It was assumed that 60 and 80 percent of federally acquired lands in the Omaha and Kansas City Districts, respectively, would have been in crop production based on estimates from the USACE real estate division (refer to Appendix F: Missouri River Recovery Management Plan, EIS Alternatives – Cost Estimates). The first model estimated the change in regional economic benefits if the agricultural lands that were acquired were all in crop production. The target acres of lands for acquisition were allocated to states based on the percent of land in the reach in the state. Assumptions of crop types on acquired lands were based on the USDA cropland data layer proportion of the most prevalent crops in the floodplain in each state. An economic input-output model, IMPLAN® Pro, was used to estimate the change in direct, indirect, and induced jobs, income, and sales from the change in the value of crop production. Including the total value of production as the direct input into the IMPLAN® Pro model likely overstates the changes in regional economic benefits because farmers are compensated for the value of sold land. To be conservative, the analysis presents total economic impacts and does not remove the direct effects.

The second model developed to consider RED impacts evaluated a change in property taxes as a result of the federal acquisition of agricultural land. As described above, it was assumed that 60 and 80 percent of federally acquired lands in the Omaha and Kansas City Districts, respectively, would have been in crop production. The evaluation used the acres and value of agricultural lands affected with location-specific property tax rates to estimate change in property tax receipts to local governments. For a full discussion of the methodology performed for the RED analysis, refer to the report "Land Use and Ownership Environmental Consequences Technical Report" available online (www.moriverrecovery.org).

Other Social Effects

Federal acquisition of lands has the potential to cause other types of effects on individuals and communities that are analyzed under the OSE account. The OSE analysis of land acquisition relied on the results of the RED analysis to determine the scale of impacts that could occur to individual and community resiliency, traditional ways of life, and economic vitality. Impacts of the alternatives on OSE are discussed qualitatively.

3.10.2.2 Summary of Environmental Consequences

Table 3-42 is a summary of the environmental consequences of federal acquisition of lands for habitat. 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

Table 3-42. Environmental Consequences Relative to Land Acquisition, 2016 Dollars

Alternative	RED	OSE	Other Impacts
Management Actions Common to All Alternatives	No RED Impacts.	No OSE impacts.	No other impacts.
Alternative 1	A loss of 2 jobs 26 jobs at the end of the implementation period across all locations. A total loss of $75,000 in property taxes at the end of the implementation period.	Negligible to small, adverse impacts to OSE.	No other impacts.
Alternative 2	A decrease of 134 jobs at the end of the implementation period across all locations relative to Alternative 1. A total decrease of $480,000 in property taxes at the end of the implementation period across all locations relative to Alternative 1.	Negligible to large, adverse impacts to OSE depending on the concentration of acquired lands.	No other impacts.
Alternatives 3–6	An increase of 18 jobs at the end of the implementation period across all locations relative to Alternative 1 A total increase of $65,000 in property taxes at the end of the implementation period across all locations relative to Alternative 1.	Negligible impacts to OSE.	No other impacts.

3.10.2.3 Impacts from Management Actions Common to All Alternatives

Management actions common to all alternatives include predator management, vegetation management, and human restriction measures. These actions are not expected to have any impacts on land use and ownership located along the Missouri River because none of these actions will require a change in land ownership or use of private lands.

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

Under Alternative 1, the MRRP would continue to construct SWH to support recovery of the pallid sturgeon. This includes acquiring private lands from willing sellers when necessary to support the creation of SWH. Under Alternative 1, the USACE would purchase approximately 1,109 acres that were previously in crop production from Ponca to Rulo and 4,158 acres from Rulo to the mouth of the Missouri River over the 15-year implementation period.

Regional Economic Development

Under Alternative 1, a reduction in agricultural production as a result of the federal acquisition of lands would result in adverse impacts to local and regional economies. For all acquired lands across all geographies during the implementation period there would be an estimated total loss of 26 jobs, $1.2 million in labor income, and $5.6 million in sales. With the highest number of acres affected, Missouri is expected to experience the most adverse impacts, with a total loss of approximately 21 jobs, $839,000 in labor income, and sales of approximately $3.7 million (Table 3-43). The land acquisition would be gradual over the implementation period. Missouri would experience the greatest adverse impacts to jobs and income, with a reduction of 21 job and $840,000 in labor income after the end of the implementation period. These adverse impacts would be long term and relatively small because the land purchases would not occur at one time

and would occur broadly across the lower river, but could be locally large if acquired lands were concentrated in one area. However, since the RED impacts described here include the direct effect, impacts are likely to be overstated because the land owners would be directly compensated with the federal purchase of the land.

Table 3-43. Reduction in Regional Economic Activity from Agricultural Land Acquisition under Alternative 1, 2016 Dollars

Impact	State				Total
	Nebraska	Iowa	Kansas	Missouri	
Estimated Federal Acres Acquired in Crop Production over the Implementation Period	554	554	208	3,958	5,267
Reduction in Direct, Indirect, and Induced Sales over 15 Years resulting from Land Acquisition under Alternative 1	−$614,166	−$658,270	−$197,503	−$3,688,364	−$5,158,303
Reduction in Direct, Indirect, and Induced Employment over 15 years resulting from Land Acquisition under Alternative 1	−1.8	−2.0	−0.6	−21.4	−25.8
Reduction in Direct, Indirect, and Induced Labor Income over 15 years resulting from Land Acquisition under Alternative 1	−$140,402	−$129,143	−$44,577	−$839,146	−$1,153,267

Table 3-44 summarizes the loss in property tax receipts associated with the total acres of land assumed to be acquired over the implementation period. In total, across all locations there could be a loss of up to $75,000 in property tax revenue to local governments from the change in land ownership. The greatest loss in property tax receipts for local governments would be in Nebraska because the state of Nebraska assigns a relatively high value to agricultural lands compared to the other states. These reductions in property tax receipts would not occur at one time and would be spread over the 15-year implementation period. As a result, the adverse impacts to local governments associated with property tax reductions would be small in most cases. However, if acquired lands were concentrated in one county, these impacts could be notable, especially for small rural counties. Under a worst-case scenario, if all lands were acquired in one county in Nebraska the total loss in property taxes would be $24,600. Because PILT would be available to local governments to offset these losses in tax base, the adverse impacts are likely to be small.

Table 3-44. Change in Property Tax under Alternative 1 from Agricultural Land Acquisition, 2016 Dollars

Type of Impact	State				Total
	Nebraska	Iowa	Kansas	Missouri	
Change in Property Tax for All Acquired Lands in Crop Production under Alternative 1	−$24,623	−$21,010	−$6,662	−$22,847	−$75,143

Note: Positive changes compared to Alternative 1 indicate increases in regional economic benefits, while negative changes indicate decreases in regional economic benefits relative to Alternative 1.

Other Social Effects

Agriculture, historically, has been a critical economic component and way of life for many of the communities within the region evaluated under this analysis. Total targeted acres for acquisition of lands that would have previously been in crop production are estimated to be 1,109 acres between Ponca and Rulo, Nebraska and 4,158 between Rulo and the mouth of the Missouri River under Alternative 1. With total agricultural floodplain acres from Ponca to Rulo of 970,332 and Rulo to the mouth of the river of 560,839, the land acquisition targets represent 0.1 percent and 0.7 percent of agricultural lands in the floodplain in these reaches, respectively. The change in employment associated with reduction in agriculture production under Alternative 1 associated with land acquisition does not represent a large share of total employment in any of the counties located in the floodplain. Changes in land use and ownership could have adverse impacts to individual and community resiliency and economic vitality if acquisition of lands were concentrated in only one or two locations. If lands were acquired in multiple locations, there would be negligible changes to other social effects in these communities.

Conclusion

Under Alternative 1, the USACE would purchase approximately 1,109 agricultural acres between Ponca and Rulo and 4,158 agricultural acres between Rulo and the mouth of the river over the 15-year implementation period. Acquisition of land under Alternative 1 is expected to have a small, adverse impact on local economies and governments. For all acquired lands across all geographies during the implementation period, employment is expected to decline by 26 jobs, $1.2 million in labor income, and $5.2 million in sales. Missouri is expected to experience the majority of these adverse impacts. Property taxes are also expected to decline with additional land acquisition which would negatively impact local governments. In total, for all acreage expected to be acquired, there could be a loss of up to $75,000 in property tax revenue to local governments from the change in land ownership. The greatest loss in property tax receipts for local governments would be in Nebraska. Alternative 1 would not have significant impacts from land acquisition activities because the RED and OSE impacts are small; land acquisition would likely be gradual over the implementation period; and PILT would be available to local governments

3.10.2.5 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 represents the USFWS projection of the management actions that would be implemented as part of the 2003 Amended BiOp RPA. Under Alternative 2, considerably more early life stage habitat for the pallid sturgeon would be created than under Alternative 1.

Regional Economic Development

Under Alternative 2, a potential reduction in agricultural production as a result of federal acquisition of lands would result in adverse impacts to local and regional economies. Alternative 2 would result in about six times the amount of agricultural acres to be acquired for pallid sturgeon early life stage habitat over the implementation period compared to Alternative 1. Under Alternative 2, the location of the land acquisition would shift slightly, with larger portions of land to be acquired in the Ponca to Rulo reach.

Table 3-45 summarizes the RED impacts associated with the federal land acquisition under Alternative 2. When compared to Alternative 1, Alternative 2 would result in $6.2 million less income and 134 fewer jobs across all locations at the end of the implementation period after all

lands have been acquired. In Missouri, land acquisition under Alternative 2, would result in a reduction of 103 jobs and $4 million in labor income. Land purchases in Kansas would have a negligible impact on employment and regional economic conditions. Overall, relative to Alternative 1, the adverse impacts to regional economic conditions under Alternative 2 in a relatively larger economic context would be long term and relatively small. However, if the concentration of acquired lands over the implementation period is in one location or a number of locations in a small rural region with limited economic activity, the adverse impacts could be relatively large in relation to the small economy. These results may overestimate RED impacts because they include direct economic impacts and do not account for compensation land owners would receive for the acquired lands.

Table 3-45. Change in Regional Economic Activity under Alternative 2 Relative to Alternative 1, 2016 Dollars

Impact	State				Total
	Nebraska	Iowa	Kansas	Missouri	
Estimated Federal Acres Acquired in Crop Production	4,666.5	4,666.5	1,206.5	22,923.1	33,462.6
Change in Sales Relative to Alternative 1 for All Acquired Lands in Crop Production	−$4,555,399	−$4,882,523	−$948,531	−$17,713,799	−$28,100,253
Change in Employment Relative to Alternative 1 for All Acquired Lands in Crop Production	−13.1	−14.7	−3.1	−102.9	−133.7
Change in Labor Income Relative to Alternative 1 for All Acquired Lands in Crop Production	−$1,041,394	−$957,878	−$214,085	−$4,030,095	−$6,243,452

Note: Positive changes compared to Alternative 1 indicate increases in regional economic benefits, while negative changes indicate decreases in regional economic benefits relative to Alternative 1.

Under Alternative 2, property tax receipts in all four states would be adversely impacted relative to Alternative 1 from land acquisition activities. Table 3-46 summarizes the impacts to property values. Across multiple locations in each state or in a relatively larger more diverse economic context, the adverse impacts to local governments associated with property tax reductions under Alternative 2 would be long term and relatively small. If acquired lands were concentrated in one or two rural counties, there could be relatively long-term, large, and adverse impacts compared to Alternative 1. A worst case scenario would result in a loss of $183,000 in total tax revenues to local governments if all lands were acquired in one county in Nebraska in the implementation period relative to Alternative 1. The PILT would help reduce these adverse impacts to these local governments.

Table 3-46. Change in Property Tax under Alternative 2 Relative to Alternative 1, 2016 Dollars

Type of Impact	State				Total
	Nebraska	Iowa	Kansas	Missouri	
Change in Property Tax for All Acquired Lands in Crop Production Relative to Alternative 1	−$182,638	−$155,834	−$31,997	−$109,727	−$480,196

Note: Positive changes compared to Alternative 1 indicate increases in regional economic benefits, while negative changes indicate decreases in regional economic benefits relative to Alternative 1.

Other Social Effects

Total targeted acres for acquisition of lands are estimated to be 9,333 acres in the Ponca to Rulo reach and 24,130 in the Rulo to the mouth of the river reach under Alternative 2. With total agricultural floodplain acres in Ponca to Rulo of 970,389 and Rulo to the mouth of 560,839, the land acquisition targets represent from 1.0 percent and 4.3 percent of agricultural lands in the floodplain in these reaches, respectively.

Over the implementation period, up to 103 jobs would be affected in Missouri. If all lands were acquired from only one or two counties by the end of the implementation period, up to 124 jobs could be affected. While farming and agriculture is an important way of life along much of the Missouri River, changes in land use and ownership associated with the USACE purchasing lands from willing sellers does not represent a threat to this traditional way of life in the counties being evaluated. Alternative 2 would generally result in small to negligible, adverse impacts to individual and community resiliency, traditional ways of life, and economic vitality but could be large if the acquisition of lands were concentrated in one or two locations.

Conclusion

Overall, relative to Alternative 1, the adverse impacts to regional economic conditions under Alternative 2 in a relatively larger economic context would be long term and relatively small. However, if the concentration of acquired lands over the implementation period is in one location or a small number of locations in a rural region with limited economic activity, the adverse impacts could be relatively large in relation to that small economy. Alternative 2 would result in $6.2 million less in income and 134 fewer jobs across all locations at the end of the implementation period after all agricultural lands have been acquired relative to Alternative 1. The adverse impacts to local governments associated with property tax reductions under Alternative 2 would be long term and relatively small with total reductions in taxes ranging from $32,000 and $183,000 relative to Alternative 1 depending on the state at the end of the implementation period. Due to the fact that land acquisition would be gradual over the implementation period and PILT would be available to local governments, these adverse impacts are likely to be small over the implementation period. While farming and agriculture is an important way of life along much of the Missouri River, changes in land use and ownership associated with USACE purchasing lands from willing sellers over the 15-year implementation period would not represent a threat to this traditional way of life in the counties being evaluated.

Alternative 2 would not have significant impacts from land acquisition activities because adverse impacts to regional economic conditions would be small, impacts associated with property tax reductions would be small, and impacts to individual and community resiliency, traditional ways of life, and economic vitality would be negligible to small.

3.10.2.6 Alternatives 3–6

The anticipated targeted acres under Alternatives 3–6 for the creation of early life stage habitat for the pallid sturgeon would be the same. Under all of these alternatives, 1,418 acres of land would be acquired for the creation of habitat to support the pallid sturgeon, which is less than the estimated land acquisition acreage for SWH under Alternative 1 (5,267 acres).

Regional Economic Development

Under Alternatives 3–6, a reduction in agricultural production as a result of the federal acquisition of lands would result in adverse impacts to local and regional economies. However, because fewer lands would be acquired under Alternatives 3–6 than would be acquired under Alternative 1, these alternatives show reduced adverse RED impacts (Table 3-47). Under Alternatives 3–6, no land would be acquired in the Ponca to Rulo reach and, thus Nebraska and Iowa would experience no change in economic activity. The impacts under Alternative 3–6 would be gradual and the change in economic activity would never represent a large share of total employment or income, even if all of the impacts occurred in one county. Compared to Alternative 1, Alternatives 3–6 would have a small change in regional economic conditions compared to Alternative 1 and would be negligible in comparison to even small rural economies, with an increase in 18 jobs during the implementation period associated with the acquisition of all lands relative to Alternative 1.

Table 3-47. Change in Regional Economic Activity under Alternatives 3–6 Relative to Alternative 1, 2016 Dollars

Type of Impact	State				Total
	Nebraska	Iowa	Kansas	Missouri	
Estimated Total Federal Acres Acquired in Crop Production	0.0	0.0	70.9	1,346.7	1,417.6
Change in Sales Relative to Alternative 1 for All Acquired Lands in Crop Production	$614,166	$658,270	$130,174	$2,431,000	$3,833,610
Change in Employment Relative to Alternative 1 for All Acquired Lands in Crop Production	1.8	2.0	0.4	14.1	18.3
Change in Labor Income Relative to Alternative 1 for All Acquired Lands in Crop Production	$140,402	$129,143	$29,381	$553,081	$852,006

Note: Positive changes compared to Alternative 1 indicate increases in regional economic benefits, while negative changes indicate decreases in regional economic benefits relative to Alternative 1.

Local governments would realize a small reduction in adverse RED impacts under Alternatives 3–6 in property tax collections in Kansas and Missouri with a reduction in the number agricultural acres that would be acquired relatively to Alternative 1. There would be no impacts in Nebraska and Iowa. At the end of the implementation period, Alternatives 3–6 would result in relatively lower losses in (beneficial impacts to) property tax revenues ranging from $4,400 and $25,000 depending on the state compared to Alternative 1 (Table 3-48). These reduced adverse impacts relative to Alternative 1 are likely to be negligible to local government budgets. PILT would reduce adverse impacts to local governments associated with any land acquisition that would occur under these alternatives.

Table 3-48. Change in Property Tax per Year under Alternatives 3–6 Relative to Alternative 1, 2016 Dollars

Type of Impact	State				Total
	Nebraska	Iowa	Kansas	Missouri	
Change in Property Tax for All Acquired Lands in Crop Production Relative to Alternative 1	$24,623	$21,010	$4,391	$15,059	$65,083

Note: Positive changes compared to Alternative 1 indicate increases in regional economic benefits, while negative changes indicate decreases in regional economic benefits relative to Alternative 1.

Other Social Effects

Total targeted acres for acquisition of lands are estimated to be 1,418 in Rulo to the mouth of the river reach and no acres in the Ponca to Rulo reach. With total agricultural floodplain acres in Rulo to the mouth of the river of 560,839, the land acquisition target represents 0.3 percent of agricultural lands in the floodplain in these reaches. Total change in employment would increase by up to 14 jobs relative to Alternative 1 (largest impact in Missouri) which does not represent a large share of employment in any county. While farming and agriculture is an important way of life along much of the Missouri River, changes in land use and ownership associated with the USACE purchasing lands from willing sellers does not represent a threat to this traditional way of life in the counties being evaluated. Alternatives 3–6 would result in a negligible change in impacts to individual and community resiliency, traditional ways of life, and economic vitality relative to Alternative 1.

Conclusion

Land acquisition under these alternatives would continue to a lesser degree than Alternative 1, thus, these alternatives result in a reduced adverse impact to local economies and governments when compared to Alternative 1. At the end o the implementation period, Alternatives 3–6 would result in relatively higher property tax revenues ranging from $4,400 and $25,000 depending on the state compared to Alternative 1. These beneficial impacts are likely to be negligible to local government budgets. Additionally, PILT would further reduce any adverse impacts to local governments associated with any land acquisition that would occur under these alternatives. Alternatives 3–6 would result in negligible impacts to individual and community resiliency, traditional ways of life, and economic vitality relative to Alternative 1.

Alternative 3–6 would not result in significant impacts from land acquisition activities because land acquisition under these alternatives would occur to a lesser degree than under Alternatives 1 and 2. As a result, impacts of federal land purchases under these alternatives would have reductions in adverse RED losses to local economies and government revenues due to the relatively larger tax base compared to Alternatives 1 and 2.

3.10.2.7 Tribal Resources

There are a number of Tribes with lands within the Missouri River floodplain in the lower river in Nebraska, Iowa, and Kansas. The acquisition of lands for pallid sturgeon early life stage habitat would likely not include transactions with Tribes; most of the lands acquired by the federal government from willing sellers are from private landowners. The indirect, adverse effects to

regional economic conditions in Nebraska, Kansas, and Iowa would be negligible under all alternatives; therefore, there would be negligible, adverse impacts to Tribes.

3.10.2.8 Climate Change

The influence of climate change would likely cause adverse impacts to agricultural producers along the Missouri River, which may affect landowners' perspectives on selling their lands, but is unlikely to have a notable impact on the federal acquisition of lands. However, because climate change would occur gradually, there would be negligible impacts on regional economic conditions and fiscal receipts associated with the federal acquisition of lands. Therefore, it is assumed that the conclusions described for each alternative would not vary substantially under the expected climate change scenario.

3.10.2.9 Cumulative Impacts

Past, present, and reasonably foreseeable future actions contribute considerable effects on land use and ownership within the floodplain. Changes to existing land use and ownership can occur through cumulative actions or influences on agriculture, urban and infrastructure development, and policies or legislation. Changes in land use and ownership can have impacts on the regional economy as well as on property tax receipts to local governments.

Impacts to agricultural production can result from USACE activities and programs as well as many other policies, programs, and economic influences. Land use changes also result from NRCS programs that establish habitat areas through riparian buffers or easements within agricultural areas.

Large-scale federal agricultural policies that alter the agricultural landscape can have considerable impacts on land use and ownership changes. Farm subsidies have played and continue to play an important and beneficial role for agriculture operations in this region. The 2014 Farm Bill includes two programs that are important for corn and soybeans, two of the most important crops grown in the Missouri River basin. Both crops are covered by the Price Loss Coverage program, which entitles producers to additional payment in the event that price per unit of production falls below a certain level. The Agriculture Risk Coverage program works similarly to the Price Loss Coverage program and provides revenue to farms on a countywide basis when revenue per acre falls below a per-acre revenue guarantee (EPA 2015). Both of these programs likely impact the amount of acreage that is maintained in agriculture production. Although the tax credit for ethanol expired at the end of 2011, these types of subsidies have historically played a major role in the number of acres of corn or other crops grown in the United States (Pear 2012).

Ongoing urban, residential, commercial, and industrial development on lands within the floodplain, including transportation and utility corridor development, can replace lands that were previously producing agricultural products. Although reductions in agricultural production in the region would adversely affect jobs and income, the conversion of land from agricultural to urban uses can result in beneficial impacts on the regional economy through increased tax revenues and the creation of additional opportunities for employment.

The actions described previously would result in both adverse and beneficial cumulative impacts to land use and ownership, with implications for the regional economy as well as changes in property tax receipts to local governments. Cumulative impacts of the past, present, and reasonably foreseeable future actions along with those of Alternatives 1–6 would result in both

adverse and beneficial impacts to the regional economic impacts associated with land use and ownership changes. The relative amount of acreage being acquired by the USACE for early life stage habitat for the pallid sturgeon is very small in size compared to the total acreage included in the floodplain and inconsequential compared to the total amount of acres in agriculture production in the counties adjacent to the mainstem Missouri River.

The contribution of Alternative 1 and Alternatives 3–6 to the adverse cumulative impacts in the context of other past, present and reasonably future plans and actions would be negligible. Under Alternatives 3–6, there would slightly fewer acres purchased to support the early life stage habitat for the pallid sturgeon, with slight benefits to regional economic conditions and fiscal receipts compared to Alternative 1, although the change would be negligible even in small rural economies. Although the federal acquisition of lands would result in some loss of property taxes, jobs, labor income, and sales, the contribution to adverse cumulative impacts to land use and ownership within the floodplain from Alternative 1 and Alternatives 3–6 would be negligible in comparison to the larger agricultural economy in the region and small and adverse only if lands were purchased in a concentrated area. The contribution of Alternative 2 to cumulative impacts would be small, with potentially larger adverse impacts in Missouri if the land acquisition is concentrated in one area.

3.11 Commercial Sand and Gravel Dredging

3.11.1 Affected Environment

Sand and gravel have been dredged or excavated from the Missouri River in the state of Missouri since the 1930s. Early dredging removed sand and gravel to aid in river navigation, and the materials removed were used for a variety of commercial uses. Beginning in the 1930s, an active commercial sand and gravel industry developed to supply the construction industries including road construction in the region. Dredging for commercial purposes gradually increased as populations along the Missouri River from the confluence with the Mississippi River to near Rulo, Nebraska, expanded in the latter half of the 1900s. By 1958, dredging operations along the river were producing approximately 1 million tons annually; and over the next 20 years, grew to exceed 3 million tons. Dredging production stabilized around 7.5 million tons in the early 2000s, and then fell to 4.6 million tons in 2009 due to the economic recession (USACE 2011). In March 2011, the Record of Decision for Authorization of Commercial Sand and Gravel Dredging on the Missouri River, reduced the permitted tonnage to be extracted from the Kansas City segment (RM 357 to RM 391) due to riverbed degradation. In December 2015, the Commercial Sand and Gravel Dredging permit was renewed. The permitted tonnage in the St. Joseph segment was reduced, the permitted tonnage in the Kansas City segment remained the same, and the annual permitted tonnage in the Waverly segment was increased with incrementally higher levels allowed until 2020.

3.11.1.1 Dredging Operations

Dredging for sand and gravel on the lower Missouri River is generally conducted by using dredges mounted on movable barges. The dredged material is passed through screens and settling-sorting equipment to achieve a desired grain size distribution that meets material specifications for various commercial uses. The sand and gravel retained are loaded onto a barge and transported from the dredge site to an onshore sand plant. Following offloading at the sand plant, empty barges return to the dredge site for reloading. At the sand plant, the sand and gravel are further processed and stacked according to material type. The sand and gravel product is then loaded into trucks and transported for use. Semi-trailer trucks are the primary mode of transporting sand and gravel to the location of end use.

Dredge operators prefer to dredge at locations upstream of the sand plant. This allows loaded barges to travel downstream with the current and empty barges to travel back upstream. River currents in the lower Missouri River are swift, and pushing loaded barges upstream is more costly in terms of fuel consumption. Dredging typically takes place no more than 7–10 miles upstream of a company's sand plant and typically no more than 3–9 miles downstream. This range is dictated by the travel times to move loaded barges to the plant, offload, and return to the dredging site, as well as the associated fuel costs. Extending the range of dredging upstream from a sand plant would require using additional barges and tugs to maintain full-time operation of the dredge. Some companies contract for dredging and delivery of dredged sand and gravel, causing some dredging equipment to be relocated to different reaches or segments of the lower Missouri River. Six dredging companies currently operate on the Missouri River between St. Joseph and St. Charles, Missouri.

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. Table 3-49 summarizes the production of Missouri River construction

sand and gravel from 2010 through 2015 on the Missouri River. Figure 3-51 depicts the amount dredged in specified segments.

Table 3-49. Annual Production of Construction Sand and Gravel from the Missouri River (2010-2015), Production in Tons

Market Area	River Mile	2010	2011	2012	2013	2014	2015	Average
St Joseph	391–498	227,484	130,722	176,347	164,228	202,118	261,704	193,767
Kansas City	357-391	1,142,492	1,010,451	862,399	884,043	779,826	570,102	874,885
Waverly	250-357	587,716	309,026	467,680	715,055	828,351	1,075,684	663,919
Jefferson City	130–250	1,234,050	1,168,375	1,046,415	1,029,350	1,275,875	1,101,585	1,142,608
St. Charles	0–130	902,781	904,448	616,399	834,855	1,018,017	1,053,886	888,398
	Total	**4,094,523**	**3,523,022**	**3,169,239**	**3,627,531**	**4,104,187**	**4,062,961**	**3,763,577**

Source: USACE 2015b. 2010-2015 MoRiverCommSandDredgingExtraction.xlsx.

Figure 3-51. Missouri River Average Annual Tonnage Dredged from 2010 to 2015

Every five years the dredgers must reapply for Department of the Army permits required under Section 404 of the CWA and Section 10 of the Rivers and Harbors Act.

In 2003 and 2004, the USACE Kansas City District received 10 applications from commercial sand and gravel companies for permits to extract sand and gravel from the LOMR. In August 2007, the USACE Kansas City District authorized four applicants to continue existing dredging operations; the remaining six applications for new or inactive dredging operations were not approved (USACE 2007). In conjunction with its review of the applications, the USACE Kansas City District determined that substantial river bed degradation was occurring in portions of the LOMR. The reaches of the river most degraded–Kansas City, Jefferson City, and St. Charles–were found to coincide with areas where commercial sand and gravel dredging was the greatest.

Additional concerns were that (1) dredging and associated river bed degradation could be contributing to impacts on habitats of federally listed threatened or endangered species; and (2) lowered water levels associated with river bed degradation were affecting the operation of municipal and industrial water intakes and the structural integrity of other public infrastructure.

In March 2011, the USACE issued a Record of Decision (ROD) that reauthorized the Missouri River commercial dredging permits and in December 2015 the permits were renewed with a few changes to the tonnage allowed in two segments. The annual permitted extraction amounts by river segment are summarized in Table 3-50.

Table 3-50. Dredging Permits by Ton until 2020 (Measured in Tons)

Segment*	St. Joseph (RM 391 to 498)	Kansas City (RM 357 to 391)	Waverly (RM 250 to 357)	Jefferson City (RM 130 to 250)	St. Charles (RM 0 to 130)	Total
2011	860,000	1,200,000	1,140,000	1,630,000	1,710,000	**6,540,000**
2012	860,000	900,000	1,140,000	1,630,000	1,710,000	**6,240,000**
2013	860,000	850,000	1,140,000	1,630,000	1,710,000	**6,190,000**
2014	860,000	800,000	1,140,000	1,630,000	1,710,000	**5,880,000**
2015	860,000	540,000	1,140,000	1,630,000	1,710,000	**5,880,000**
2016	330,000	540,000	1,778,000	1,630,000	1,710,000	**5,350,000**
2017	330,000	540,000	1,778,000	1,630,000	1,710,000	**5,509,500**
2018	330,000	540,000	1,778,000	1,630,000	1,710,000	**5,669,000**
2019	330,000	540,000	1,778,000	1,630,000	1,710,000	**5,828,500**
2020	330,000	540,000	1,778,000	1,630,000	1,710,000	**5,988,000**

Source: ROD for Authorization of Commercial Sand and Gravel Dredging on the lower Missouri River March 2011; USACE 2015b

Note: *Represents location of dredging in the Missouri River based on river segments.

3.11.1.2 Market and Demand for Missouri River Sand and Gravel

Commercial sand and gravel dredged from the lower Missouri River are used primarily in the construction industry, including road and highway construction. The Missouri Department of Transportation is one of the largest customers of sand from the Missouri River. Similarly,

Missouri River sand and gravel, specifically from the Kansas City area, is used by the Kansas Department of Transportation in transportation projects in eastern Kansas. It is estimated that approximately 8.0 percent of the total tonnage of commercial sand and gravel dredged from the Missouri River is used by state transportation departments for roadway construction projects. Between 2004 and 2008, approximately 57.0 percent of total sand used by the Missouri Department of Transportation came from the Missouri River, which equates to approximately 497,000 tons annually. Between 2005 and 2009, the Kansas Department of Transportation used an average of 56,076 tons of Missouri River sand per year. The Kansas Department of Transportation obtained most of its Missouri River sand from the Kansas City area (92.9 percent); the remaining 7.1 percent is obtained from the St. Joseph area.

Approximately 92.0 percent of commercial sand and gravel from the Missouri River is used by the general public for residential and nonresidential construction (excluding state transportation projects). According to commercial dredgers and industry research, the primary area served by existing dredging operations is generally 2,050 miles from the sand plants. Assuming that the area is generally defined by a 25-mile radius around each distribution point, 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.

3.11.1.3 Access to Materials

Dredges require access to the river to operate. River flows, the volume of water in the river, and sediment conditions directly affect whether or not dredges are able to operate and how much sediment is being transported for extraction. Changes in those physical conditions can directly affect access to extract (i.e., sand and gravel). Benefits and losses can be directly associated with changes in physical conditions, which can affect dredging facilities operating conditions and in turn operational costs. The optimal flows for dredging operations are those associated with full service operation for navigation (approximately 41,000 cfs in the segment areas). When flows are above that threshold, the dredge may have to use more resources to travel upstream due to the current. Dredgers can typically operate at decreased flows; however, there is an increased cost in operations. The operator may need to use more fuel and time to transport the materials in the river. There could also be extra maintenance costs to the dredges because of the low water.

Typically, the dredge barges need approximately 8 to 9 feet of water for normal operations. Most operators can dredge 10 to 30 feet but some can go up to 45 feet below the surface of the water.

3.11.1.4 Availability of Materials

The elevation of sediment in the river affects dredging operations. Permitted dredging amounts have been reduced in the Kansas City segment due to riverbed degradation. Dredging companies seek alternate sources of material when Missouri River sand and gravel are not available, such as floodplain mining, dredging from other rivers, and manufactured sand.

Sand and gravel must meet a certain standard. The dredged material is passed through screens and settling-sorting equipment to achieve a desired grain size distribution that meets material specifications for various commercial uses. The material ranging from 0.1 to 4.0 millimeters (mm) is typically retained and the unwanted material, typically larger than 4.0 mm, is discharged back to the river.

3.11.2 Environmental Consequences

Commercial sand and gravel dredging takes place on the lower portion of the Missouri River, from St. Joseph, Missouri to downstream of St. Charles, Missouri. The alternatives evaluated include management actions with potential to affect river flows, channel form, and river stage. The commercial sand and gravel dredging impacts analysis focuses on determining if changes in river and reservoir conditions associated with each of the MRRMP-EIS alternatives could result in an impact to commercial sand and gravel dredging operations. This section summarizes the commercial sand and gravel impacts assessment methodology and presents the results of the assessment. A detailed description of the methodology and results can be found in the “Commercial Sand and Gravel Dredging Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

3.11.2.1 Impacts Assessment Methodology

Alternative means of achieving species objectives are evaluated for their effects on commercial sand and gravel dredging operations. The impacts to commercial sand and gravel dredging are evaluated using three of the four accounts: NED, RED, and OSE. The accounts framework enables consideration of a range of both monetary and non-monetary values and interests that are expressed as important to stakeholders and Tribes, while ensuring impacts are not double-counted. The following section provides a brief overview of the overall methodology for evaluating impacts to the commercial sand and gravel dredging as well as the approach for each account.

The analysis used the change in sedimentation rates from seven USGS gages located at different points between St. Joseph and Hermann, Missouri. Flow release scenarios were produced in the Management Plan HEC-ResSim model, then routed downstream by the Management Plan Unsteady HEC-RAS Model. A detailed description of the methodology and results can be found in the “Commercial Sand and Gravel Dredging Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

The No Action Alternative is considered the baseline against which the other alternatives are measured. Under the No Action Alternative, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, the No Action Alternative does 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.

National Economic Development

The objective of the NED commercial dredging sand and gravel impact analysis was to estimate the changes in NED values that may occur due to management actions implemented under the alternatives. One part of the NED analysis was to evaluate the change in the sediment accumulation rate to determine if the amount of sediment is impacted, which could impact availability of sand and gravel material. The second part of the NED analysis for commercial dredging sand and gravel was based on impacts related to transportation of material, which focused on two values: (1) the navigation transportation savings; and (2) the change in non-routine repair, replacement, and rehabilitation (R, R, & R) costs. The first part of the commercial sand and gravel analysis is described in this section. The second part associated with NED navigation is discussed in the Environmental Consequences discussion in Section 3.15, Navigation. A detailed description of both analyses including data sources, calculations, and

assumptions can be found in the “Commercial Sand and Gravel Dredging Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org). A higher rate of sediment accumulation is a benefit to commercial sand and gravel dredgers because there is more sediment in the river whereas a lower or negative rate of sediment accumulation is an adverse impact because there is less sediment in the river.

Regional Economic Development

The RED commercial sand and gravel dredging evaluation was based on the results of the NED commercial sand and gravel dredging evaluation. The NED analysis showed very minimal changes in the sedimentation accumulate rate under each of the MRRMP-EIS alternatives relative to Alternative 1. Given the negligible change in the sediment accumulation rate between the alternatives, the differences were not large enough to result in measurable RED impacts. Impacts of the alternatives on RED are discussed qualitatively. RED impacts associated with the change in transportation costs are addressed in the in Environmental Consequences discussion in Section 3.15, Navigation.

Other Social Effects

Changes in commercial sand and gravel dredging operations have a potential to cause other types of effects on individuals and communities in terms of individual and community well-being as well as traditional ways of life. The OSE analysis for commercial sand and gravel dredging relied on the results of the NED and RED analysis to determine the scale of impacts that could occur to individual and community well-being and economic vitality. Given the negligible change in the sediment accumulation rate between the alternatives, the differences were not large enough to result in measurable OSE impacts. Impacts of the alternatives on OSE are discussed qualitatively.

3.11.2.2 Analysis Assumptions

The following assumptions were used for the impacts analysis for commercial sand and gravel dredging:

- This analysis uses preliminary flow data and sediment data. Flow release scenarios were produced in the Management Plan HEC-ResSim model, and then routed downstream by the Management Plan Unsteady HEC-RAS Model. Each alternative includes a permutation of historical data that spans from March 1, 1930 to December 31, 2012.
- The sediment data was derived from unpublished work which David Heimann (USGS) provided in support of sediment modeling for the Management Plan. Heimann interpolated daily suspended sediment loads and sediment loads < 0.0625 mm at each of the following gages from 1993 to 2013.
- The relationship between flow and sediment load do not change over time. This analysis is not an actual sediment budget due to differences in period of analysis and other simplifications.

3.11.2.3 Summary of Environmental Consequences

The environmental consequences relative to commercial sand and gravel dredging are summarized in Table 3-51. Under all alternatives there would be a negligible change (less than

one percent increase or decrease) in the sediment accumulation rate. The different management alternatives would not have a significant impact on the sediment accumulation based on the analysis performed.

The one-time spawning cue test (Level 2) release that might 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.

Table 3-51. Environmental Consequences Relative to Commercial Sand and Gravel Dredging

Alternative	NED Impacts	RED Impacts	OSE Impacts	Summary of Impacts
Management Actions Common to All Alternatives	NED impacts not calculated for management actions common to all alternatives	RED impacts not calculated for management actions common to all alternatives	OSE impacts not calculated for management actions common to all alternatives	Other impacts not calculated for management actions common to all alternatives
Alternative 1	Negligible	Negligible	Negligible	Negligible change in the sediment accumulation rate
Alternative 2–6	Negligible	Negligible	Negligible	Same as Alternative 1

Note: Refer to the environmental consequences discussion of Section 3.15, Navigation, for the NED, RED, and OSE accounts; the change in transportation of materials is included in Section 3.15, Navigation.

3.11.2.4 Impacts from Management Actions Common to All Alternatives

A number of management actions are common to all alternatives and would have no potential to impact commercial sand and gravel dredging in terms of the sediment accumulation rate. These actions include vegetation management, predator management, human restriction measures, and propagation and augmentation. The results from the evaluation of all alternatives showed that there was less than a one percent net change, either positive or negative, in the change in sedimentation rate. The change in sedimentation rate was calculated at each USGS gage and then compiled to include two reaches in Missouri: St. Joseph to Kansas City and Kansas City to Hermann. This analysis suggests very little difference in long-term, large-reach sediment accumulation in any of the alternatives. Small differences among alternatives are within the uncertainty of the input data.

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

Under Alternative 1 (as fully described in Chapter 2.0) there would be negligible impacts to the sediment accumulation rates in the St. Joseph, Kansas City, Waverly, and Jefferson City reaches. The negligible decrease in sediment accumulation is due to the variability in hydrology and change in hydrologic conditions over the period of analysis. These impacts are discussed in more detail in the “Commercial Sand and Gravel Dredging Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org). The creation of emergent sandbar habitat does not occur in the reach of the river that commercial sand and

gravel dredging occurs, thus there are no impacts. Table 3-52 shows sediment accumulation by reach. For impacts from construction, refer to Section 3.15, Navigation.

Table 3-52. Sediment Accumulation Compiled by Reach: Alternative 1

			Alternative 1
Reach 1	St. Joseph to Kansas City	Sediment Accumulation (tons/year)	−2,000,560
Reach 2	Kansas City to Hermann	Sediment Accumulation (tons/year)	−2,721,094

Mechanical Habitat Construction

For early life stage pallid habitat, Alternative 1 would construct 1,129 acres between Rulo, Nebraska, and the Kansas River; and 937 acres between the Kansas River and Osage River. Generally, these actions involve mechanical manipulation of the riverbed, bank, and/or channel structures. Despite the potential to affect channel structures, these actions are not likely to impact the commercial sand and gravel dredging industry. Furthermore, each project will be designed to not impact other authorized purposes including sand and gravel dredging as described in Section 2.5.3.1. Prior to any site-specific construction project, monitoring will be conducted to detect any issues such as degradation or a change in sediment accumulation in the river.

Mechanical construction of emergent sandbar habitat would not occur in the same reaches of the river as commercial sand and gravel dredging, thus no impacts would occur from this action or associated activities.

National Economic Development

The NED analysis for commercial sand and gravel dredging under Alternative 1 shows a negative sediment accumulation rate, which implies a certain degree of degradation. Given the small change in the sediment accumulation, the impacts are anticipated to be negligible. The NED analysis as it pertains to transportation of material is captured under the navigation business line since the dredgers are using the river to transport commodity. Refer to the Environmental Consequences discussion in Section 3.15, Navigation, for results.

Regional Economic Development

The RED analysis for commercial sand and gravel dredging evaluated if there are any impacts to the economic output/sales, income, or employment by industry and region due to a change in the sediment accumulation rate. Alternative 1 would not result in adverse impacts to the commercial sand and gravel dredging industry due to the change in sediment accumulation, and RED impacts would be negligible.

Other Social Effects

Changes in the commercial sand and gravel dredging industry due to a change in sediment accumulation are not anticipated to cause other types of effects on individuals and communities such as community well-being, noise, and aesthetics. Alternative 1 would not result in any adverse impacts to the commercial sand and gravel dredging industry or other social effects due to changes in sediment accumulation.

Conclusion

None of the impacts from Alternative 1 would be significant for commercial sand and gravel dredging. Impacts to the three accounts evaluated under Alternative 1 were negligible and would not have an impact on the sediment accumulation based on the analysis performed.

3.11.2.6 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 (as fully described in Chapter 2.0) is anticipated to result in negligible impacts to the commercial sand and gravel dredging industry when compared to Alternative 1. Alternative 2 resulted in an overall 0.50 percent (22,174 tons/year) increase in sediment accumulation from Alternative 1.

Mechanical Habitat Construction

When compared to Alternative 1, for early life stage pallid habitat, 2,439 additional acres would be constructed under Alternative 2 between Rulo, Nebraska, and the Kansas River; 3,307 acres between the Kansas River and Osage River; and 529 acres between the Osage River and the mouth of the Missouri River. Generally, these actions involve mechanical manipulation of the riverbed, bank, and/or channel structures. Despite the potential to affect channel structures, these actions are not likely to impact the commercial sand and gravel dredging industry because each project will be designed to not impact other authorized purposes including sand and gravel dredging as described in Section 2.5.3.1. Prior to any site-specific construction project, monitoring will be conducted to detect any issues such as degradation or a change in sediment accumulation in the river.

Mechanical construction of emergent sandbar habitat would not occur in the same reaches of the river as commercial sand and gravel dredging, thus there are no impacts that would occur from this action or associated activities.

National Economic Development

Impacts to the commercial sand and gravel dredging industry would be negligible due to the measurable but very small percent change from Alternative 1. The difference in the NED analysis between Alternative 1 and Alternative 2 is less than one percent (0.50 percent) and Alternative 2 NED analysis results are summarized in Table 3-53.

Table 3-53. Sediment Accumulation Compiled by Reach: Alternative 2

Reach Number	Reach Span	Sediment Impact	Alternative 1	Alternative 2
Reach 1	St. Joseph to Kansas City	Sediment Accumulation (tons/year)	−1,470,560	−1,462,568
		Change from Alternative 1 (tons/year)	—	7,992
		Percent Change from Alternative 1	—	0.5%
Reach 2	Kansas City to Hermann	Sediment Accumulation (tons/year)	−3,359,094	−3,344,912
		Change from Alternative 1 (tons/year)	—	14,182
		Percent Change from Alternative 1	—	0.4%

Reach Number	Reach Span	Sediment Impact	Alternative 1	Alternative 2
Overall	St. Joseph to Hermann	Sediment Accumulation (tons/year)	−4,829,654	−4,807,480
		Change from Alternative 1 (tons/year)	—	22,174
		Percent Change from Alternative 1	—	0.5%

Regional Economic Development

Under Alternative 2, RED impacts would be similar to those as described in the National Economic Development section for Alternative 2.

Other Social Effects

Changes in sediment accumulation are not anticipated to cause other types of effects on individuals and communities such as community well-being, noise, and aesthetics. Alternative 2 would not result in adverse impacts to the commercial sand and gravel dredging industry or other social effects due to changes in sediment accumulation and Other Social Effects would be negligible because the percent change from Alternative 1 is less than one percent.

Conclusion

Impacts from Alternative 2 would not be significant for commercial sand and gravel dredging. Impacts to the three accounts evaluated under Alternative 2 were negligible and would not have an impact on the sediment accumulation based on the analysis performed.

3.11.2.7 Alternative 3 – Mechanical Construction Only

Alternative 3 (as fully described in Chapter 2.0) is anticipated to result in negligible impacts to the commercial sand and gravel dredging industry when compared to Alternative 1. Alternative 3 resulted in an overall 0.10 percent (6,013 tons/year) increase in sediment accumulation from Alternative 1. These impacts are described in more detail below.

Mechanical Habitat Construction

When compared to Alternative 1, for early life stage pallid habitat, 670 additional acres would be constructed under Alternative 3 between Rulo, Nebraska, and the Kansas River; 1,389 acres between the Kansas River and Osage River; and 460 acres between the Osage River and the mouth of the Missouri River. Generally, these actions involve mechanical manipulation of the riverbed, bank, and/or channel structures. Despite the potential to affect channel structures, these actions are not likely to impact the commercial sand and gravel dredging industry because each project will be designed to not impact other authorized purposes including sand and gravel dredging as described in Section 2.5.3.1. Prior to any site-specific construction project, monitoring will be conducted to detect any issues such as degradation or a change in sediment accumulation in the river.

Mechanical construction of emergent sandbar habitat would not occur in the same reaches of the river as commercial sand and gravel dredging, thus no impacts would occur from this action or associated activities.

National Economic Development

Any NED impacts to the commercial sand and gravel dredging industry under Alternative 3 would be negligible due to the measurable but very small percent change from Alternative 1. The difference in the NED analysis between Alternative 1 and Alternative 3 is less than one percent (0.10 percent). Alternative 3 NED analysis results are summarized below in Table 3-54.

Table 3-54. Sediment Accumulation Compiled by Reach: Alternative 3

Reach Number	Reach Span	Sediment Impact	Alternative 1	Alternative 3
Reach 1	St. Joseph to Kansas City	Sediment Accumulation (tons/year)	−1,470,560	−1,471,237
		Change from Alternative 1 (tons/year)	—	−677
		Percent Change from Alternative 1	—	0.0%
Reach 2	Kansas City to Hermann	Sediment Accumulation (tons/year)	−3,359,094	−3,352,404
		Change from Alternative 1 (tons/year)	—	6,690
		Percent Change from Alternative 1	—	0.2%
Overall	St. Joseph to Hermann	Sediment Accumulation (tons/year)	−4,829,654	−4,823,641
		Change from Alternative 1 (tons/year)	—	6,013
		Percent Change from Alternative 1	—	0.1%

Regional Economic Development

Under Alternative 3, RED impacts would similar to those as described in the National Economic Development section for Alternative 3.

Other Social Effects

Changes in sediment accumulation are not anticipated to cause other types of effects on individuals and communities such as community well-being, noise, and aesthetics. Alternative 3 would not result in adverse impacts to the commercial sand and gravel dredging industry or other social effects due to changes in sediment accumulation.

Conclusion

Impacts from Alternative 3 would not be significant for commercial sand and gravel dredging. Impacts to the three accounts evaluated under Alternative 3 were negligible and would not have an impact on the sediment accumulation based on the analysis performed.

3.11.2.8 Alternative 4 – Spring ESH Creating Release

Alternative 4 (as fully described in Chapter 2.0) is anticipated to result in negligible impacts to the commercial sand and gravel dredging industry when compared to Alternative 1. Alternative

4 resulted in an overall 0.20 percent (−8,102 tons/year) decrease in sediment accumulation from Alternative 1.

Mechanical Habitat Construction

When compared to Alternative 1, for early life stage pallid habitat 670 additional acres would be constructed under Alternative 4 between Rulo, Nebraska, and the Kansas River; 1,389 acres between the Kansas River and Osage River; and 460 acres between the Osage River and the mouth of the Missouri River. Generally, these actions involve mechanical manipulation of the riverbed, bank, and/or channel structures. Despite the potential to affect channel structures, these actions are not likely to impact the commercial sand and gravel dredging industry because each project will be designed to not impact other authorized purposes including sand and gravel dredging as described in Section 2.5.3.1. Prior to any site-specific construction project, monitoring will be conducted to detect any issues such as degradation or a change in sediment accumulation in the river.

Mechanical construction of emergent sandbar habitat would not occur in the same reaches of the river as commercial sand and gravel dredging, thus no impacts would occur from this action or associated activities.

National Economic Development

Any NED impacts to the commercial sand and gravel dredging industry under Alternative 4 would be negligible due to the measurable but very small percent change from Alternative 1. The difference in the NED analysis between Alternative 1 and Alternative 4 is less than one percent (−0.20 percent). Alternative 4 NED analysis results are summarized below in Table 3-55.

Table 3-55. Sediment Accumulation Compiled by Reach: Alternative 4

Reach Number	Reach Span	Sediment Impact	Alternative 1	Alternative 4
Reach 1	St. Joseph to Kansas City	Sediment Accumulation (tons/year)	−1.470.560	−1.466.448
		Change from Alternative 1 (tons/year)	—	4,112
		Percent Change from Alternative 1	—	0.3%
Reach 2	Kansas City to Hermann	Sediment Accumulation (tons/year)	−3.359.094	−3.371.307
		Change from Alternative 1 (tons/year)	—	−12,213
		Percent Change from Alternative 1	—	−0.4%
Overall	St. Joseph to Hermann	Sediment Accumulation (tons/year)	−4,829,654	−4,837,756
		Change from Alternative 1 (tons/year)	—	−8,102
		Percent Change from Alternative 1	—	−0.2%

Regional Economic Development

Under Alternative 4, RED impacts would be similar to those as described in the National Economic Development section for Alternative 4.

Other Social Effects

Changes in sediment accumulation are not anticipated to cause other types of effects on individuals and communities such as community well-being, noise, and aesthetics. Alternative 4 would not result in adverse impacts to the commercial sand and gravel dredging industry or other social effects due to changes in sediment accumulation.

Conclusion

Impacts from Alternative 4 would not be significant for commercial sand and gravel dredging. Impacts to the three accounts evaluated under Alternative 4 were negligible and would not have an impact on the sediment accumulation based on the analysis performed.

3.11.2.9 Alternative 5 – Fall ESH Creating Release

Alternative 5 (as fully described in Chapter 2.0) is anticipated to result in negligible impacts to the commercial sand and gravel dredging industry when compared to Alternative 1. Alternative 5 resulted in an overall 0.50 percent (22,634 tons/year) increase in sediment accumulation from Alternative 1. These impacts are described in more detail below.

Mechanical Habitat Construction

When compared to Alternative 1, for early life stage pallid habitat, 670 additional acres would be constructed under Alternative 5 between Rulo, NE and the Kansas River; 1,389 acres between the Kansas River and Osage River; and 460 acres between the Osage River and the mouth of the Missouri River. Generally, these actions involve mechanical manipulation of the riverbed, bank, and/or channel structures. Despite the potential to affect channel structures, these actions are not likely to impact the commercial sand and gravel dredging industry because each project will be designed to not impact other authorized purposes including sand and gravel dredging as described in Section 2.5.3.1. Prior to any site-specific construction project, monitoring will be conducted to detect any issues such as degradation or a change in sediment accumulation in the river.

Mechanical construction of emergent sandbar habitat would not occur in the same reaches of the river as commercial sand and gravel dredging, thus no impacts would occur from this action or associated activities.

National Economic Development

It is anticipated that NED impacts to the commercial sand and gravel dredging industry under Alternative 5 would be negligible due to the measurable but very small percent change from Alternative 1. The difference in the NED analysis between Alternative 1 and Alternative 5 is less than one percent (0.50 percent). Alternative 5 NED analysis results are summarized below in Table 3-56.

Table 3-56. Sediment Accumulation Compiled by Reach: Alternative 5

Reach Number	Reach Span	Sediment Impact	Alternative 1	Alternative 5
Reach 1	St. Joseph to Kansas City	Sediment Accumulation (tons/year)	−1,470,560	−1,464,110
		Change from Alternative 1 (tons/year)	—	6,450
		Percent Change from Alternative 1	—	0.4%
Reach 2	Kansas City to Hermann	Sediment Accumulation (tons/year)	−3,359,094	−3,342,910
		Change from Alternative 1 (tons/year)	—	16,184
		Percent Change from Alternative 1	—	0.5%
Overall	St. Joseph to Hermann	Sediment Accumulation (tons/year)	−4,829,654	−4,807,020
		Change from Alternative 1 (tons/year)	—	22,634
		Percent Change from Alternative 1	—	0.5%

Regional Economic Development

The RED impacts under Alternative 5 are similar to those as described in the National Economic Development section for Alternative 5.

Other Social Effects

Changes in sediment accumulation are not anticipated to cause other types of effects on individuals and communities such as community well-being, noise, and aesthetics. Alternative 5 would not result in adverse impacts to the commercial sand and gravel dredging industry or other social effects due to changes in sediment accumulation.

Conclusion

Impacts from Alternative 5 would not be significant for commercial sand and gravel dredging. Impacts to the three accounts evaluated under Alternative 5 were negligible and would not have an impact on the sediment accumulation based on the analysis performed.

3.11.2.10 Alternative 6 – Pallid Sturgeon Spawning Cue

Alternative 6 (as fully described in Chapter 2.0) is anticipated to result in negligible impacts to the commercial sand and gravel dredging industry when compared to Alternative 1. Alternative 6 resulted in an overall 0.40 percent (18,424 tons/year) increase in sediment accumulation from Alternative 1. These impacts are described in more detail below.

Mechanical Habitat Construction

When compared to Alternative 1, for early life stage pallid habitat, 670 additional acres would be constructed under Alternative 6 between Rulo, NE and the Kansas River; 1,389 acres between the Kansas River and Osage River; and 460 acres between the Osage River and the mouth of the Missouri River. Generally, these actions involve mechanical manipulation of the riverbed, bank, and/or channel structures. Despite the potential to affect channel structures, these actions are not likely to impact the commercial sand and gravel dredging industry because each project

will be designed to not impact other authorized purposes including sand and gravel dredging as described in Section 2.5.3.1. Prior to any site-specific construction project, monitoring will be conducted to detect any issues such as degradation or a change in sediment accumulation in the river.

Mechanical construction of emergent sandbar habitat would not occur in the same reaches of the river as commercial sand and gravel dredging, thus no impacts would occur from this action or associated activities.

National Economic Development

It is anticipated that NED impacts to the commercial sand and gravel dredging industry under Alternative 6 would be negligible due to the measurable but very small percent change from Alternative 1. The difference in the NED analysis between Alternative 1 and Alternative 6 is less than one percent (0.40 percent). Alternative 6 NED analysis results are summarized below in Table 3-57.

Table 3-57. Sediment Accumulation Compiled by Reach: Alternative 6

Reach Number	Reach Span	Sediment Impact	Alternative 1	Alternative 6
Reach 1	St. Joseph to Kansas City	Sediment Accumulation (tons/year)	−1,470,560	−1,466,387
		Change from Alternative 1 (tons/year)	—	4,173
		Percent Change from Alternative 1	—	0.3%
Reach 2	Kansas City to Hermann	Sediment Accumulation (tons/year)	−3,359,094	−3,344,843
		Change from Alternative 1 (tons/year)	—	14,251
		Percent Change from Alternative 1	—	0.4%
Overall	St. Joseph to Hermann	Sediment Accumulation (tons/year)	−4,829,654	−4,811,230
		Change from Alternative 1 (tons/year)	—	18,424
		Percent Change from Alternative 1	—	0.4%

Regional Economic Development

The RED impacts under Alternative 6 are similar to those as described in the National Economic Development section for Alternative 6.

Other Social Effects

Changes in sediment accumulation are not anticipated to cause other types of effects on individuals and communities such as community well-being, noise, and aesthetics. Alternative 6 would not result in adverse impacts to the commercial sand and gravel dredging industry or other social effects due to changes in sediment accumulation.

Conclusion

Impacts from Alternative 6 would not be significant for commercial sand and gravel dredging. Impacts to the three accounts evaluated under Alternative 6 were negligible and would not have an impact on the sediment accumulation based on the analysis performed.

3.11.2.11 Climate Change

Increased precipitation and streamflow, increased sediment inflow, and increased irregularity of floods and droughts would be the three main climate change variables that could potentially influence sediment and, therefore, the commercial sand and gravel dredging industry under Alternatives 1–6.

The increased precipitation and streamflow variable assumes that increased precipitation would accelerate sediment movement through the system. As both the sediment coming into the system and leaving the system would be increased, the change to net sediment accumulation, which is based on the difference between sediment coming and going out, would be muted.

Higher rates of precipitation are typically associated with increased sediment generation from the watershed. Most of this increase would be in fine sediments which do not accumulate on the riverbed. However, some portion may be coarse sediments, which would likely have a positive impact on the commercial sand and gravel industry because there would be more material in the river. For a detailed discussion on climate change impacts to hydrology and geomorphology see Section 3.2.2.7. It is unlikely that climate change would increase or alter the impacts of Alternatives 1–6 to the point at which they would become significant to commercial sand dredging operations.

3.11.2.12 Cumulative Impacts

Past, present and future actions that would affect river flows, the volume of water in the river, and sediment conditions directly affect whether or not dredges are able to operate and how much sediment is being extracted and transported. These actions would include operations and maintenance of the Missouri River Reservoir System; BSNP; water withdrawals for agriculture, municipal, and industrial use; and floodplain development, among others. For a detailed discussion of cumulative actions that affect river flows, volume, and sediment conditions see Section 3.2.2.8.

In the limited reaches on the Missouri River between St. Joseph and St. Charles, Missouri where commercial sand dredging occurs, impacts under Alternatives 1–6 would be negligible. Specifically, changes from the action alternatives (2–6) would each result in equal to or less than 0.5 percent change. When combined with other actions, significant adverse cumulative impacts from Alternatives 1–6 would be unlikely, although depending on river flows, the volume of water in the river, and sediment conditions impacts could be adverse or beneficial. Alternatives 1–6 contribution to the overall cumulative impacts would be negligible.